SCIENCE.

FRIDAY, SEPTEMBER 19, 1884.

COMMENT AND CRITICISM.

THE Philadelphia meeting of the American association is credited with being the most successful up to this time. The total attendance was 1,249. Great Britain contributed 303; Pennsylvania, 246; New York, 161; Massachusetts, 87; District of Columbia, 84; New Jersey, 58; Ohio, 57; Connecticut, 32; and Virginia, 22. The membership was increased nearly twenty-five per cent, 515 new members being elected, and the number of members up to this meeting being 2,033. The number of papers read was larger than ever before; and it is to be hoped that the weeding-out of the trivial matters so often offered was carried to a greater extent than usual. There was a general feeling that there was too much going on. A large portion of the physicists were engaged as examiners at the electrical exhibition, and were, of course, interested in the meetings of the electrical conference. Somewhat less science, and somewhat more time to enjoy the junketing, would be more in accordance with the desires of many, if one may judge from the opinions expressed on the way home. A proposition to confine the reading of papers to the mornings would have met with many supporters.

THE International association, which has been so earnestly advocated by Dr. C. S. Minot, has now a more assured existence; thanks to the fund of twenty thousand dollars, which will be established through the liberality of Mrs. Elizabeth Thompson. Of this fund, five thousand dollars have already been paid to the association; and five thousand more will be paid next year on condition of ten thousand being raised from other sources. The income from this fund is to be devoted to research. Not only did Mrs. Thompson give liberally to this new society, but also gave one thousand dollars to the American association for the advancement of science, to be used in researches on light and heat. Mrs. Thompson takes great interest in the recent marvellous advances in the application of electricity and felt a desire to contribute, as far as lay in her power, to the advancement of our knowledge of the forces of nature. Appreciating the unity of energy, whether displayed as heat or light or electricity, Mrs. Thompson gave the money for researches as to the nature and sources of light and heat, in the hope that more may be learned of the connection which may exist between heat and light and electricity.

CONGRESS passes laws to favor science and literature in importations; and the treasury officials, under the pretence of protecting the revenue, interpose vexatious requirements, which defeat the purpose of congress. Are the treasury officials so devoid of administrative skill that they cannot devise some way to further the end of congress, and protect the revenue at the same time? Have colleges, for instance, no rights under the laws which treasury officials are bound to respect? What is the use of congress giving colleges the right to import current periodicals, duty-free, if these protectors of the revenue cause delays and expense, to incur which were worse for the colleges than to pay duty? Under recent decisions of the treasury, each successive part of a periodical for a public institution must be made the matter of a distinct oath, involving time and money, and the passage and re-passage of documents between the college and its agent at the port of entry. If all the wits these treasury officials have spent in devising these vexations are not exhausted by the process, they may perhaps calculate what new endowments colleges will now need to help these officials protect the revenue! It is hard to contemn the witless.

Among the meetings which have just been held in Philadelphia, was a friendly and informal gathering of some of the contributors to *Science*. About thirty persons came together, and listened to some statements which were made on the part of the managers, and expressed their views in respect to the position which this journal has taken and may take. The tone of the meeting was in all respects encouraging. A review which had been made of the subscription-list, by our publisher, shows that these pages now reach the chief scientific institutions and the chief scientific workers of the country. An effort will next be made to secure an extension of the circulation among other intelligent and educated classes.

Our contributors were invited at this meeting, and are always invited, to bear in mind that not only *Science* as a journal, but science in higher and broader aspects, will be best promoted by enlisting the attention of the general reader to the results which are attained in all departments of knowledge. This can only be done if our friends will write as persons who are specially informed, to persons who are not specially informed, on the subjects treated in our columns. One of our most valued contributors says that the man who is eminent in one department may have only an ordinary knowledge of other subjects: the greatest astronomer may be a tyro in entomology; the best of chemists may have no conception of elliptic functions. *Science* in its articles should be readable throughout; and, if our friends will continue to help us, we shall soon reach success.

LETTERS TO THE EDITOR.

*** *Correspondents are requested to be as brief as possible. The writer's name is in all cases required as proof of good faith.*

Phosphorescence in the deep sea.

The following paragraph by Dr. Studer,[1] the naturalist of the *Gazette*, has probably escaped the notice of those who have lately written regarding the protective nature of the phosphorescence of pelagic animals. He closes a general description of phosphorescence in marine animals, and the probable nature of it, as follows: 'Immer aber ist es ein von aussen kommender reiz, welcher das leuchten hervorbringt, so dass wir vielleicht die erscheinung als eine schutzvorrichtung für das tier betrachten dürfen.' He further says, on the same page, 'Wir dürfen vielleicht annehmen, dass es vorwiegend rote und orange strahlen sind, welche in diese tiefen gelangen (2-300 faden), dass die blauen und violetten schon vorher absorbiert und reflektirt werden. Daraus würde sich dann die vorwiegend rote färbung der Crustaceen als eine schutzfärbung erklären lassen, wie die vorwiegend blaue der am tage erscheinenden geschöpfe.'

Alexander Agassiz.

Newport, Sept. 12, 1884.

[1] Ueber einige wissenschaftliche ergebnisse der gazellen-expedition . . . Verhandlungen des zweiten deutschen geographentages. Berlin, 1882.

Fish remains in North-American Silurian rocks.

The Rev. W. S. Symonds seems somewhat disturbed by my letter of July 11. He apparently fears lest the honor of yielding the earliest fish-remains should pass from England to North America.

My note to *Science* was purposely made very short, but I was quite aware of the fact that a *single* specimen of Scaphaspis Ludensis (not fish-remains) had been found in the *lower* Ludlow rocks. Mr. Symonds will excuse my reminding him that Sir C. Lyell mentions this discovery by Mr. Lee at Leentwardine in 1859. The statement may be found in his Elements for 1865: not having the book at hand, I cannot name the page. Professor Lankester also, in 1869, refers this species to the *lower* Ludlow. To have been unacquainted with the fact would therefore be inexcusable.

Mr. Symonds will probably be surprised to learn that I am a native of the county (Herefordshire) in which he has himself done so much excellent geological and archeological work. I have been familiar from boyhood with much of the country which forms the 'hunting-grounds' of the Woolhope club, and visited some of them as lately as 1879.

As an abstract of my paper will shortly appear, I refrain from giving details at present.

E. W. Claypole.

B. A. A. S., Montreal, Aug. 29.

Korean curios.

The article in *Science*, No. 82, entitled 'Korean curios,' contains some errors, excusable, however, when one considers the difficulty of speaking through two languages, and getting the information filtered back through the same channel. For these corrections, and the brief information embodied in them, I am indebted to one of the Korean embassy, Mr. Yu, who has been with me constantly for several months, and who now speaks very good English.

The ring worn upon the thumb of Min Yong Ik (who, by the way, is not a prince, but a noble) is the Chinese thumb-ring worn in archery, by means of which the bowstring is drawn back. These rings are often very expensive. I was shown one in Canton valued at one hundred and fifty dollars, and some are valued much higher. The Korean archery-ring for the thumb is nearly always of horn, and entirely different in shape.

The amber bead is not necessarily imported; as amber is found in Korea, and is recognized by the Koreans as being a kind of gum from pine. They regard the best and oldest, which is of light color, as being three thousand years old, the darkest and poorest as being one thousand years old.

The button represented in Fig. 4 can only be worn by high officials. Officers of the first rank wear

quartz ones, while officers of the second and third rank wear gold ones. These buttons are secured to the customary band made of hair and not of velvet.

The reason given for leaving the wife at home — namely, that her clothes would not have stood the wear of the journey — was a polite excuse only. Social custom would have rendered it impossible for any of them to bring their wives with them.

In regard to the extraordinary crystals, my informant's brother has seen the region where they occur, and says the wonders of it are beyond description. He describes it as bordering the shore for a distance, in one measurement, of fifteen miles.

Mr. Kunz is quite right in regarding them as crystals of quartz; for Mr. Yu says they are white, and also like glass, and assume branching forms like trees, columns, etc., and tower at greater heights even than the dimensions given by Mr. Kunz. This region is on the eastern coast of Korea, and has never been visited by foreigners. The Chinese have in vain tried to get permission to visit this place.

Edward S. Morse.

A COMPARATIVE STUDY OF THE ASSOCIATIONS.

To us on this side of the Atlantic, the opportunity to profit by the contrast of the two association meetings just closed ought not to be lost; and the desire to take advantage of it may justify a somewhat extended comparison of the two associations.

Concerning what may be called the 'physical features' of the two meetings, their relation to each other may be readily seen by an inspection of the following statistics: At the Montreal meeting, the total registered attendance was 1,773, of which nearly half crossed the ocean, and about six hundred were classed as 'old' members. The total number registered was somewhat below the average of the past ten years, which was 1,889, not including last year's meeting. The largest meeting ever held by the British association was at Manchester, in 1861, when the registry was 3,944; the smallest, in recent years, at Swansea, in 1880, the number being 899. The number of registered members at Philadelphia was 1,261, the greatest number ever on the rolls of the American association at one meeting. It is not unlikely that the excess of more than five hundred in the membership of the British association over that of the American is to be partially attributed to the rule of the British association, which confines the privileges of attendance to members of one class or another; while the policy of the American association has been to invite and to welcome all who are interested in the proceedings, regardless of membership.

At the Montreal meeting, the total number of papers read was 327. At Philadelphia, 304 papers were read. The number of papers on mathematical and physical science was ten greater in the American than in the British association. In the latter, however, the number of physical papers was greatly in excess, as those concerning pure mathematics were disposed of by a sub-section in a single day.

In addition to the regular papers, there were, in the various sections of the British association, more than fifty reports presented, coming from committees appointed at previous meetings for the consideration of special subjects. Of similar reports in the American association, it can hardly be said that there were any, such as were offered being mostly confined to a few words declaring 'progress,' asking for continuation, and promising something in the future; and even this much was only obtained after much labor on the part of the presiding officer.

As to the general character of the meetings, it may be said that both were above the average. Sir William Thomson declared, at the closing session of the British association, that it was one of the most satisfactory ever held; and both he and Lord Rayleigh declared that the meetings of section A were far above the average.

It can be affirmed without boasting, that Americans (citizens of the United States) contributed in no small degree to insure this success. At least forty, or about one-eighth, of the entire number of papers read, came from them. They joined in several of the important discussions, and generally with credit; and some of them — Newcomb, Rowland, and possibly others — presided over sections at various times. It is well worthy of note, that, of the five papers recommended to be published *in extenso*, one was from Professor Gray, and another from Professor Thurston.

The Philadelphia meeting of the American

association was doubtless, all things considered, the most successful yet held. The work done in sections was, in general, of a higher order than usual; and we are, in turn, indebted to the visiting members of the British association for valuable assistance in 'bringing up the average.' Many of them presented papers, and took part in the discussions which now and then arose in various sections.

The greatly inferior quantity, if not quality, of the work done by our special committees, is unquestionably due, to a great extent, to a fact already referred to in these pages. The committees of the British association are aided by grants of money, as much as $7,500 being allowed at the Montreal meeting. Could the committees of our association obtain such grants, their work would undoubtedly be vastly more satisfactory. Besides, being thus relieved from the purely mechanical drudgery of the work, the feeling of responsibility would be much greater, and each committee would recognize the necessity of justifying its existence, and of showing that the money given as aid had been well invested.

On the whole, it will be admitted that the British association does its work upon a higher plane than that occupied by the American. Its sectional work shows more that is really new and of lasting value, and less that is trifling; although there has been a steady and healthful improvement in the character of the American association during several years past. It may be well to remark here, that there are at least a few of the ablest and best men in American science who have continued to exhibit no interest in the American association; and that, if the association is not precisely what they believe it ought to be, the fault lies at their own doors. No others should or could be so influential in shaping its course and moulding its character.

It may be well, however, to turn from the consideration of these graver differences between the two associations, and notice briefly some of those distinctions which are more personal in their nature, between the members themselves.

Our English cousins certainly possess an enviable capacity for recognizing the amusing side of affairs. At Montreal one came to expect pleasant little outputs of the mildest humor in the midst of the profoundest scientific dissertations. Your formula might be torn to shreds by severe criticism, but your fun was welcomed without examination.

In the matter of paying compliments, and moving thanks in an easy and graceful manner, our English cousins have the advantage of us. It is the almost universal custom for the chairman of the section to thank the reader of a paper, and often in elaborate terms. This consumes a good deal of time, and it is a question whether such wholesale compliment is desirable. It was observed, however, that the distinguished and genial presiding officer of one of the sections made use of two quite different formulae for expressing his appreciation of the merits of the paper: in one case hoping "that the section would join him in thanking Professor —— for his interesting and important communication upon this subject;" and in another, "that the section would join him in thanking Professor —— for his communication upon this interesting and important subject." The importance of the proper arrangement of words was never shown to better advantage.

The undemonstrative character of the American as compared with the Englishman was exhibited in the public meetings of the two associations. The American association has seldom had so felicitous an address from a retiring president as that of Professor Young, and the probability that it was not generally heard throughout the vast academy of music was the only excuse for the fact that its many good points failed of that recognition which they so richly deserved. This failure was commented upon by an Englishman in a remark to the writer, that such an address would have been much more frequently applauded in England. "We constantly interrupt a speaker to applaud him," he said, "if for no other reason than to afford him a breathing-spell."

THE CARSON-CITY ICHNOLITES.

THE fossil footprints upon the layers of sandstone in the quarry at Carson City, in the state of Nevada, have excited much interest and discussion, not only by reason of the number and grouping of animals represented, but especially because some of the tracks have a rough resemblance to such footprints as a man of great size might make in walking upon soft mud. Elaborate reports and memoirs have already appeared,[1] regarding these tracks; and in California and Nevada there has been, and continues to be, a great difference of opinion as to the origin of the tracks which resemble the imprints of human feet. These tracks occur in a light, gray-colored, coarse sandstone formation, of the mammalian age of the tertiary, lying in nearly horizontal beds, with thin partings or layers of clay at intervals. The section at one point directly above one of the series of tracks is as follows: —

Sandy clay	18	inches.
Sandstone	4	feet.
Clay	½	inch.
Sandstone	16	feet.
Fine clay	2 feet 2	inches.
Coarse sandstone	10	"
Sandy clay, with tracks . . .	3	"
Sandstone	18 to 24	"
Clay layer, with tracks .	1 to 2	"
Sandstone below the quarry floor,	38	feet.

The tracks represent at least ten different animals, as follows: Elephas, or the mammoth; elk, or American reindeer; Bos, or buffalo; horse; wolf; tiger; peccary; Mylodon, or a giant sloth; the so-called 'Homo Nevadensis;' birds.

Bones and teeth of the elephant and of the horse have also been found in the sandstone beds above the ichnolites. There are also casts of shells of Anodonta, and an abundance of casts of reeds and aquatic plants, directly overlying the layers of silt or mud on which the tracks are found.

The sequence of events is plainly recorded in these beds. The floor of the quarry marks the close of a period of strong currents of water, depositing sand. A period of quiescence ensued, with the deposition of a fine clay or silt. This was drained of water, and became firm enough for animals to walk upon it and leave their tracks. This layer is separated from a second clayey layer by about eighteen inches of sand, marking an overflow and a second period of quiescence and drying-up. The tracks are most numerous and distinct upon this second layer. Immediately over it we find several inches in thickness of fine clayey sediment, penetrated by aquatic plants, with the remains of fresh-water shells, indicating the existence of a shallow lake or lagoon for a considerable period. The overlying coarse sandstones show the influx of strong currents, bearing the sand and the bones of animals from some point beyond, and higher than the tracks.

It is probable that these deposits were formed near the mouth of a comparatively large stream, subject to floods, and flowing into a shallow lake. Such conditions are not unlike those we now find all along the eastern base of the Sierra Nevada, where mountain torrents pour out into elevated valleys without outlet, and form broad lakes, which vary greatly in their extent at different seasons of the year. During the season of the melting of the snows, the lakes cover a much greater area than in the dry season, when the rivers cease to flow, and the lake-water disappears by evaporation. Large areas of the shores of such lakes then become exposed, and are gradually dried. If, as in the case of the deposits under consideration, the upper clayey sediments are underlaid by coarse sandstone, the clay layer is rapidly dried by under-draining, and affords a firm footing for animals in search of water. This need of water may account for the number of animals which crowded together at this place. It is possible, also, that a warm spring existed there, as at the present time, drawing animals toward it from the surrounding deserts.

The sandstone surface is distinctly marked by raindrop pits and by ripple or wave marks.

Tracks of the mammoth or elephant.

These appear as a series of circular depressions from three to six inches in depth, and averaging twenty inches in diameter. The most important series is forty feet long, and has ten distinct footprints. Most of these have a raised margin or border of clay in ridges, due to the great pressure and squeezing of the clay.

[1] Footprints found at the Carson state prison. By H. W. HARKNESS, M.D. *Proc. Cal. acad. sc.*, Aug. 7, 1882.

On certain remarkable tracks found in the rocks of Carson quarry. By JOSEPH LECONTE. *Proc. Cal. acad. sc.*, Aug. 27, 1882.

Prehistoric footprints in the sandstone quarry of the Nevada state prison. Description by CHARLES DRAYTON GIBBES, C.E., Sept. 4, 1882, to accompany diagrams of footprints.

HARKNESS, *Proc. Cal. acad. sc.*, August, 1883. (Abstract in *New-York evening post.*)

O. C. MARSH, *Amer. journ. sc.*, No. 152 [3] xxvi., August, 1883.

The Carson footprints. Report of Professor GEORGE DAVIDSON, president of the California academy of sciences, August, 1883.

Ichnolites of the Carson quarry. W. P. BLAKE. *Trans. Conn. acad. arts and sciences*, February, 1884.

The stride of the elephant which made the tracks here represented was about five feet eight inches, and the straddle three feet five inches, measuring from outside to outside.

Tracks of man (*so called*), **or mylodon (?)**

The long and curved tracks, which have excited the greatest degree of interest from their supposed human origin, extend in several different directions, but generally in straight direct lines. The longest series has forty-four tracks, and is a hundred and twelve feet long.

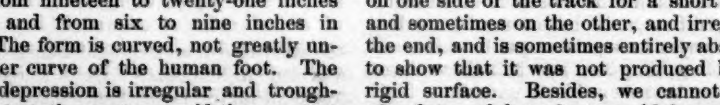
Another set of tracks is the most distinct of all, and is upon the upper layer of silt or clay, two feet above the general level of the quarry floor. A rubbing upon paper twenty-seven feet long, covers twelve tracks of this series, and shows the general form and the exact sequence and position of these tracks. The imprint on the paper being formed by rubbing with a graphite pad, it gives a more accurate idea of the shape of the tracks than any drawing made with hard, sharp outlines; for none of the outlines are sharply marked, but the depression gradually shades off into the generally plane surface. For this reason it is not easy to state definitely the exact size of these tracks. They may be said to be generally from nineteen to twenty-one inches in length, and from six to nine inches in breadth. The form is curved, not greatly unlike the inner curve of the human foot. The amount of depression is irregular and trough-like, deepest at the centre, as if the greatest pressure was exerted there; in this respect differing decidedly from the impress of a human foot, being without the heel and toe depressions, although some of the tracks show a more abrupt depression at the supposed heel than at the other end.

10 feet.

FIG. 1.—TRACKS OF THE ELEPHANT.

In order to explain the great size of the tracks on the theory of their human origin, and, further, to explain a peculiarity in the form of some of them, it has been asserted that sandals were worn. This peculiarity consists in a flat, tabular surface or border, extending, like a terrace, from an inch to two or three inches wide along the inner margin of the track. This is thought by some to be the impress of the sandal. The tracks having this peculiarity are shown of full size in figs. 1 to 5, attached to the memoir of Dr. Harkness. While he is fully confident that these are the imprints of sandals, he points out a very significant fact, — "that the impression is upon the same plane in each of the diagrams, and that there is no indication of toe or pad or arch in any of them" (p. 7).

A critical examination of these tracks having the partial border of a flat surface, showed that this flat margin marks a parting or dividing plane in the sediments along which the clay-like layers separated; such portions, apparently, as were not crushed and broken through, being lifted off as the foot of the animal was raised and carried forward.



10 feet.

FIG. 2.—TRACKS RESEMBLING THE IMPRINT OF HUMAN FEET. (*From the plan by Gibbes.*)

The fact that it occurs irregularly, sometimes on one side of the track for a short distance, and sometimes on the other, and irregularly at the end, and is sometimes entirely absent, goes to show that it was not produced by a flat, rigid surface. Besides, we cannot conceive of a flat sandal, such as would be required to make a *flat* imprint, permitting the central part of the track to be so greatly depressed. And in walking with sandals, the toe in leaving the

track, especially in a soft, muddy surface, tends to depress, and throw back the mud towards the centre of the track, whereas the conditions in these tracks are reversed. A longitudinal vertical section of one of these tracks would be nearly as in the diagram, the greatest depression being in the middle.

FIG. 3.—CROSS-SECTION OF IMPRESSION.

The breadth of the track-way, or straddle, is the next great objection to the theory of human origin. The whole breadth is from twenty-eight to thirty inches, whereas man requires, in walking, not over ten or twelve inches. If we take the ordinary stride of a man six feet high at twenty to twenty-four inches, the ratio of the breadth of space required in walking to this step is as ten or twelve to twenty or twenty-four, or 1 : 2; while in the tracks before us the ratio is as twenty-eight to twenty-seven, the step, in fact, being less than the straddle. This alone is fatal to the bipedal theory, and in favor of the quadrupedal; for upon the quadrupedal theory the length of step is fifty-six to sixty-two inches, and, the width being twenty-eight to thirty, the ratio of the width to the length is nearly as one to two.

There are also evidences of a duplication of tracks made by the hind-feet overstepping the imprints of the fore-feet. This has been particularly pointed out by Professor Davidson in his report.

The tracks of this series all have the appearance of being made by an animal with short legs, for it is evident that there was a sliding in and out of the foot, particularly in the trough-shaped impressions of the lower horizon of clay.

When first opened, these are always filled up with a compressed mass of clay and sand; and sometimes traces of a coarse, sedgy grass or vegetation are found, as if it had been pressed down under the foot into the clay.

The opinion of Professor Marsh, that these tracks were formed by one of the edentates, is best in accord with the phenomena, and appears the more reasonable when we give due weight to the fact that some of these animals are believed to have walked partly upon the side of the foot and leg, thus carrying their great claws in such a way that they left no imprint.

Elk (?)

Of the supposed elk-tracks there are thirteen in sequence, each track from four to five inches long by three and one-half wide, average step eighty inches, and breadth of track thirteen inches.

Deer.

The series referred to the deer is twelve feet one inch in length, and includes ten tracks of an animal with a sharp-pointed hoof, triangular in form, measuring two inches by two and one-half inches.

Birds.

The bird-tracks are numerous, and are generally about six inches in length and breadth, showing four toes, as in the figure.

It is well to note that the intense interest attaching to the question of the human origin of some of the tracks has greatly overshadowed the importance, geologically, of the whole series and the lessons to be learned from them. There has not been such an important discovery of fossil tracks since the unearthing of the fossil footprints in the sandstones of the Connecticut valley. These last were discovered in 1800, and served to stimulate and to foreshadow our knowledge of the forms of life between birds and lizards. The venerable Dr. Hitchcock, the author of 'Ichnology of New England,' in contemplating the evidences of the

FIG. 4.—BIRD-TRACK.

so-called bird-tracks of the Connecticut valley, was led to exclaim, "Indeed, some of the tracks of these narrow-toed bipeds have such a resemblance to the feet of some lizard, that I anticipate the discovery of front teeth."

He cites Owen as saying, before fossil foot-prints were known, that "a single foot-mark of

a cloven hoof indicates to the observer the forms of the teeth, of all the big bones, thighs, shoulders, and of the trunk of the body, of the animal which left the mark."[1]

W. P. BLAKE.

Mill Rock, New Haven.

THE VIRULENCE OF CULTIVATED ANTHRAX VIRUS.

Experimental studies on the artificial attenuation of the infectious properties of the bacillus of Anthrax by means of cultivation. By Dr. R. KOCH, Dr. GAFFKY, and Dr. LOEFFLER.

Mittheilungen aus dem Kaiserlichen gesundheits-amte. Zweiter band. Berlin, 1884. (Extract from the publication of the imperial board of health of Germany.)

PASTEUR's announcement that the parasites of malignant Anthrax were capable of changing their characteristics when cultivated under certain conditions, and that when thus modified they could be used for protective inoculation, aroused the greatest interest among investigators. Such a statement could not be accepted without confirmation at the hands of other observers; and none were better fitted for this task than the Royal health commission of Germany, at the head of which stands Dr. Robert Koch.

The experiments, which were instituted under his direction, have been carried on for two years, and have shown, that, although the bacilli could be rendered harmless, their protective power was not so great as was expected.

The original communication of the French *savant* was not exact in the details by which the experiments were to be carried out, and Koch had to employ much time in preliminary studies. This cannot, however, be considered as lost, since many valuable facts have been obtained by it.

According to Pasteur, if the cultivations were kept at a temperature constantly maintained between 42° and 43° C., the virulence gradually decreased until the ninth day, when it was entirely lost. By removing a specimen on any day, and allowing it to germinate at a temperature of 37° C., its activity at that stage could be perpetuated, and thus any degree of virulence that was required could be preserved. Two such cultures of different strength were used for protective inoculation, the weaker of which was called the *premier*, and the stronger the *deuxième vaccin*.

Koch commenced his investigations in the following way. A mouse was injected with blood containing spores of the bacillus, which had been kept five years, and was known to be of great virulence.

The animal was killed at the end of twenty-four hours, and a minute quantity of the spleen was taken on the point of a platinum needle which had been sterilized by heat, and sown in a glass bulb containing twenty cubic centimetres of chicken-bouillon neutralized with sodic carbonate. The bulb was then sealed, and placed at once in a constant-temperature apparatus, which was kept between 42° and 43° C.

Samples were taken daily, and tested upon animals; but, contrary to the promised result, the growth was found to be as deadly for small animals on the ninth as on the first day. Further cultivation proved, however, that, in a period varying from eighteen to twenty-nine days, the infectious property was entirely lost, although the external appearance of the bacillus was unaltered. Thus far, Pasteur's assertion was substantiated, except in regard to the length of time. A portion of this was taken, and allowed to grow at an ordinary temperature for two years; and during this time there has been no evidence of a return of virulence, nor has the form changed. These bacilli are as immovable as the active ones; their ends appear sharply truncated; they form long filaments, in which are developed oval glancing spores. Vaccination with this entirely inactive form did not give immunity against inoculation with the virulent one.

Those of a slight degree of force were next tried. At the end of twenty-four days a culture was obtained which would kill mice, but not guinea-pigs or other small animals, but still did not render them safe. This particular form Koch speaks of as 'mouse anthrax.'

It was thought that perhaps this represented the second and the inactive form, the first vaccination of Pasteur. Accordingly, a sheep was tried, but it succumbed to the malignant form as quickly as ever. It was next proposed to use three or more preventive inoculations; and, accordingly, cultures from the fifteenth day were taken as the first, from the eleventh as the second, from the ninth as the third, and from the fifth as the fourth, and these were followed by the virulent form. In this manner seven sheep, seven rabbits, and eleven guinea-pigs were tried. At the end, all the rabbits and guinea-pigs, and five of the sheep, had died.

In order to determine whether there might not be some other difference, specimens of the vaccinating-material, as furnished by Pasteur through his agent, were purchased, and proved

[1] *Proc. am. assoc. ad. sc.*, xiv. 146.

in regard to their power. The first corresponded to the 'mouse anthrax' (that is, a culture from the eighteenth to the twenty-fourth day), while the second vaccination corresponded to the ninth day. Six sheep were inoculated with these; and out of these, one died after inoculation with the malignant form. As a result, it can be stated, that, after the most careful protective vaccination, an unconditional immunity against infective inoculation is not reached in all cases. Koch thinks that Pasteur's perfect success must be due to the fact that the malignant anthrax used by him was not so virulent as he himself employed.

The cause of the diminution of virulence is regarded by Pasteur as due to the action of oxygen; by Koch, on the other hand, as due to the effects of temperature alone, even so small an amount as a few tenths of a degree C. causing a marked variation in the length of time required to render the bacillus perfectly harmless. Chauveau's experiments also point in the same direction; for while it took from three to four weeks, at a temperature of 42.5° C., to reach the desired result, it could be attained in a few days at 43° C., and in a few hours at 47° C., while a few minutes sufficed if a temperature of from 50° to 53° was used. The lower, however, the temperature, the more surely is the attenuation preserved in later cultivations. When developed in the bodies of animals for several successive generations, Koch found that there was an occasional tendency, on the one hand, for a weaker form to become more powerful; and, on the other, for a stronger to become weaker. But, as a rule, the degree was preserved unaltered, as in artificial cultures.

The scientific fact that sheep could be rendered safe against inoculated anthrax was confirmed by these experiments. The question then arises, How do the vaccinated animals conduct themselves against natural infection? As is well known, different kinds of animals differ in this respect. Cattle, for example, are very refractory to artificial inoculation, while they are very often attacked from a natural source. Pasteur regards the natural source of infection as much less liable to produce the disease than the artificial. His method of placing a number of vaccinated animals in a meadow, in which notorious cases had occurred, is capable of such great errors that it cannot be relied upon for scientific accuracy.

What is the most common way in which natural infection occurs? One method analogous to inoculation is from the bites and stings of insects, who leave, at the same time, spores of the bacillus, which may be attached to their bodies. Another is by the inoculation of scratches in the mouth, caused by sharp particles of fodder.

Koch believes, however, that the intestine itself is the common place of entrance for the parasite, but only when in the condition of spores.

To show this, a portion of the spleen of an animal who had died from anthrax was put inside a small ball of potato, and placed on the back part of the tongue of a sheep. In this way any danger of wounding the mucous membrane of the mouth was avoided. (Since spores are never formed within the body, by taking a portion of the organs, as above, it was known that it was the bacilli alone that were introduced.) Every experiment failed, even after enormous doses, and thus proved that the bacilli are destroyed in the stomach, and are therefore not in a condition to produce intestinal anthrax. When, however, the bacilli were allowed to produce spores, and these were given, every animal died. The examination after death showed that the spores had developed in the intestinal tract, and the bacilli had invaded the body from these. It is therefore in the highest degree probable that the introduction of spores with the food is the most common source of natural infection. The amount would never be so great at one time as was here used; but, if smaller doses were repeatedly given, the picture of an ordinary epidemic could be nearly reproduced.

Cattle could not be obtained for experiment; but an examination made on a cow who had died from natural infection showed similar lesions in the intestines to those found in the sheep.

Animals with a single stomach could not be infected in this way.

Finally the effects of protective inoculation were tried. Ten sheep were taken: five of these were vaccinated with material obtained from Pasteur, of two different strengths; and five, according to Koch, with cultures of the fifteenth, eleventh, ninth, and fifth day. They were then fed with spores. As a result, two of the first series died, but none of the second.

From these few yet unimpeachable experiments, Koch concludes, that, for a certain number of animals, absolute immunity can be obtained; but he doubts whether a simple vaccination, with only two different degrees of attenuation of the virus, is sufficient to give perfect protection.

EISSLER'S MODERN HIGH EXPLOSIVES.

The modern high explosives, nitroglycerine and dynamite: their manufacture, their use, and their application to mining and military engineering. By MANUEL EISSLER. New York, *Wiley*, 1884. 11+395 p., illustr. 8°.

IN this work the author has sought to acquaint the engineer, the contractor, and the chemist with the composition and characteristics of the high explosives, and with their adaptation to certain purposes. He has been led to do this from "the lack of authentic information on the subject, and the great increase in the use of these explosives;" yet we find the book to be largely a compilation from such well-known works as those of Abbot, Drinker, Mowbray, and Berthelot, together with others not so well known, and from various chemical books.

Such a compilation, if properly selected, digested, and arranged, would be highly creditable, and, in the present state of the art, very useful; but unfortunately, while the fundamental plan of Eissler's book is most excellent, it is badly carried out in detail, since subjects most closely connected are treated of in widely separated places, with a consequent loss of distinctness and consecutiveness, and the introduction of an annoying repetition and sometimes of conflicting statements. Besides, from his custom of copying many of his authorities *verbatim et literatim*, he has introduced examples of most of the many systems of nomenclature known to chemistry. Add to this an obscure style, and the use of words and phrases such as 'chlor-metals,' 'protoxide of azote,' 'resting acids,' 'parchemined paper,' and the like, and we have a confusion which is most puzzling to the reader, even if he be a skilled chemist; while, if he be not, the use of a '*trituration* of soda for the determination of nitric acid,' of chloride of *lime* for use in a drying-tube, of *ammonium* as a test for the solubility of silver chloride, and the method described for the *transmutation* of a gas into a burette, may well seem unintelligible.

Throughout the work, the author has sought to give due credit to the various investigators whom he quotes; yet we observe that in some instances he errs, as when he states that the experiments on explosive gelatine, which he describes, were made in France, when, in fact, they were made in Austria by Capt. Hess, the French account of them being simply a translation of Hess's paper by Paul Barbe. On the other hand, he erroneously credits Hess with the application of the various methods described for the quantitative analysis of nitroglycerine mixtures.

Many positive statements are made which may be questioned. Thus Eissler states that the explosions of the fulminates "are very sharp from the extreme rapidity of their decomposition, but, from the small amount of gas given off, the force exercised is not very great;" while Berthelot says, "Calculation will show that no other explosive known will give in contact an instantaneous pressure at all comparable to that of mercuric fulminate." Again: Eissler asserts that "nitro-compounds of cellulose with more than 41.89 % of NO_2 contain nitric acid in the pores which is not properly washed out." This percentage corresponds to the pentanitrocellulose, and the statement is probably based on Eder's researches in 1879; but Vieille, in 1882, found that thoroughly nitrated cellulose yielded 44.27 %, corresponding to eleven atoms of NO_2 in the molecule. Other examples might be pointed out.

The above criticisms apply principally to the first third of the book. In parts ii. and iii., which are devoted to the mode of use and applications of the high explosives, the author appears more at home with his subject, which he presents in a clearer manner, and with greater precision of statement; and he has gathered material which must be of interest and use to the engineer and contractor. The perusal of this portion will also interest the general reader; as few realize to how great an extent, and for what a variety of purposes, explosive substances are used at the present day. Here he will learn that advantage is taken of the enormous potential energy of these bodies in the quarrying of stone; the mining of ores, coal, and oil; the driving of cuts and tunnels for roads; the deepening of our channels, and the removal of reefs and rocks from our harbors; the driving of piles; the clearing of fields for agriculture, and the shaking-up of the soil to prepare it for vegetation; the destruction of icy barriers, and the breaking-up of large masses of metal to fit them for the melting-furnace. The climax seems to be reached in the statement, that, in some of the hydraulic gold-mines of California, it is an almost daily occurrence to fire blasts in which twenty, thirty, or even fifty thousand pounds of explosives are used in a single charge, — an amount exceeding that used in the blowing-up of Hell Gate. Compared with this, the amount used for purely military purposes sinks into insignificance.

THE OHIO AGRICULTURAL EXPERIMENT STATION.

Second annual report of the Ohio agricultural experiment-station, for 1883. Printed by order of the state legislature. Columbus, *Myers brothers,* state printers, 1884. 207 p. 8°.

THE first impression made by this report is that of unusual industry in experimentation. A large amount of work has been done upon wheat and Indian corn, as was natural, considering the location of the station. Quite extensive feeding-experiments have been executed; and a number of minor subjects have received more or less attention, such as observations on garden-vegetables, fruits, weeds, and injurious insects, the testing of over five hundred samples of seeds as to their germinative power, experiments on cutting potatoes for seed, etc.

Over forty pages are devoted to experiments upon wheat, and nearly as many to those upon Indian corn; such subjects being considered as the comparative value of varieties, thick and thin seeding, winter protection and spring cultivation of wheat, planting at different depths for corn, methods of culture, application of fertilizers, etc. Some interesting experiments in crossing different varieties of corn are also in progress.

The feeding-experiments relate mainly to milk-production, though a few pig-feeding trials are added; showing that the same amount of food produces more rapid growth when the animals are protected from extreme cold, — a fact which has already been proved so often, and which is so fully in accord with all that we know of the effects of a low temperature on animals, that it would seem that it might now be accepted as established.

The experiments presented in this report are so good, and represent so much labor, that one can but regret that they are not better. For example: the field-experiments on wheat and corn give evidence of care in planning and in execution. They take up important subjects, and present much food for reflection to farmers; but in all candor it must be said that they *prove* nothing. Passing over the question which is now being seriously asked by eminent authorities, whether field-trials are capable of yielding trustworthy results, it is certain, that, in order that they may do so, they must be executed with all the precautions which the experience of thirty years has suggested. It is not too much to say that these experiments are not thus distinguished, though they do, indeed, compare favorably with many others; and when we find, for example, the two unmanured plots of one series yielding respectively 40.2 and 70.4 bushels of corn per acre, we must conclude that the results of such trials are to be taken with some grains of allowance. The feeding-trials, too, while in many respects carefully conducted, have just enough elements of uncertainty — short periods, estimates of amount of hay eaten, estimates of composition of food, etc. — to give rise to the constant feeling that the results may be accidental.

It is, of course, to be presumed that this station, like most others, has not the means to do all that its director would be glad to do; and a fair criticism should take into account the limitations under which such work must usually be done. At the same time, certain conditions are essential to the prosecution of scientific research; and experiments made in disregard of them are no better because that disregard is enforced.

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

PROCEEDINGS OF THE SECTION OF GEOGRAPHY.

THE meetings of the section were held in the Montreal gymnasium, which was sometimes crowded to overflowing, especially upon the appearance of Lieuts. Greely and Ray.

The president's address was listened to with marked attention. After the usual formalities were passed, the proceedings were opened by the president, who communicated a letter which he had received from Mr. Joseph Thomson, — recently returned from Africa, — from which the following is extracted: "I shall have to tell about snow-clad mountains, grassy plateaux, and sterile plains, of picturesque isolated mountains, wonderfully preserved volcanic cones and craters in which the fiery forces might have been at work the previous year, of the charming crater-lake Chala on the slopes of Kilima-njaro, the silvery sheets of Naivasha, Mtakuto, and Baringo, lying embosomed in a great valley-like depression formed by the dark and frowning mountains of Man and Lykipia. Not the least interesting subject will be that of the enormous volcanic mountains El Gon or Ligonyi.

"The people themselves are more interesting and unique than their country. The Masai are in every respect a people by themselves. They have no resemblance either to the true negroes or to the Galla and Somal who shut them in. They distinctly differ in their mode of life, their curious customs, forms

of government, and religious belief, not to speak of their curious language. I am happy to say that I have been able to determine the latitude of all points of interest by astronomical observations, as well as the longitude of Baringo and Kwa-Sunda near the Nyanza. The height of all main points has been determined by George's barometer.

"My route was from Baringo to near the Nile, almost due west, returning somewhat farther north. Kavisondo does not extend so far south, not more than 20′ south. The north-east corner of the lake, as represented on the maps, must be cut off if my observations are correct." A spirited discussion ensued, in the course of which it appeared that Mr. Thomson had had some hairbreadth escapes, and had endured the extremity of hunger. Professor Ravenstein gave a description of the physical conformation of equatorial Africa, and said that the Masai were no new race, but had been met with before. He instanced the Latooka of Sir Samuel Baker, and M'tésa, the chief of Uganda, and quondam convert of Stanley, as belonging to the same group.

The president made a communication with regard to Mr. H. H. Johnson's Kilima-njaro expedition, to the effect that he had been well received by the ruler of the district, 'King Mandalla,' and had been given every facility for the prosecution of his work of collecting specimens of natural history.

Prof. E. G. Ravenstein, the recorder of the section, read an exceedingly interesting paper on certain maps and globes of Central Africa before the seventeenth century, which exhibited a complicated river system and a congerie of lakes. It had been supposed by certain geographers of eminence, including Mr. Major, that the hydrographical features were derived from actual knowledge obtained by the Portuguese, who had thus anticipated Livingstone, Cameron, and Stanley by a couple of centuries. But this was not a correct idea; as the learned Ludolfus — if he had carried out his intention of compiling a map of the whole of Africa — would have shown, and would thus have gained a place among cartographers second only to Delisle and D'Anville.

In order to judge how far these ancient maps were based upon actual knowledge, or were merely conjectural, it would be necessary to examine the records of early exploration; and, fortunately, we are now in a position to do this, as Luciano Cordeiro had brought to light several of the most ancient Portuguese records.

After a concise account of the explorations of the ancients, Mr. Ravenstein narrated, at some length, the exploration carried on by the Portuguese. He said that their knowledge of the coast districts was pretty full; and as early as the sixteenth century they had heard of the Makoko, the great chief of the Anteke, as well as of several tribes on the middle Kongo, of the Zambeze as far as Chicova, and of a considerable portion of Abyssinia. Inland lakes were mentioned by them, but in so vague a way that their identification with our modern lakes was impossible. Even the Nyassa seems to have been unknown to them, although merchants from Sena navigated the Shiré; and an overland trade was undoubtedly carried on by the natives, for articles of Portuguese manufacture actually reached Manica overland from Loanda. But no Portuguese had ever crossed the continent; as Gregorio Quadra and Balthazar Rebello de Aragão, who attempted to do so in 1520 and 1602, had failed at the very outset.

With regard to the ancient maps, he stated that the earliest among them were mere repetitions — so far as the interior was concerned — of Ptolemy. Later on, the remarkable information given by Fra Mauro on Abyssinia was embodied in them. Ruysch's map (1508) is an illustration of Ptolemy; and if we took the more detailed maps of the period, — Pigafetta, illustrative of the 'Congo,' for instance, — and transferred the names there found to their correct position, we should find that the interior of Africa was a blank. As an example, Barcena, Coloes (from Ptolemy), Zahaf, and Saphat were names all referring to the great lake of Abyssinia, our Lake Tsana.

It followed from this, that, up to the beginning of the seventeenth century, the Portuguese had no knowledge of the centre of Africa and of its great river-systems; although subsequently they had made certain discoveries which anticipated, in a measure, the information obtained by the heroes of modern African exploration.

Mr. Trelawney Saunders described the remarkable journey of a trained native of India — Krishna, or A. K., as he is more commonly called — who penetrated regions hitherto known to us only through D'Anville's *Atlas de la Chine*, which contains maps of Tibet, derived from the surveys of Lama priests, made in continuation of the great Jesuit work, under the orders of the famous emperor Kuenten. It has been all along a most interesting feature of the researches of the native explorers in Tibet, that they have, in a remarkable degree, confirmed these Tibetian surveys, allowing some little differences easily recognized. In the present case the explorer, leaving Prjevalski's route at a point near the source of the Hoangho, struck a river, which, on placing a reduction of his work upon a reduction of the Lama survey, on the same projection and scale, falls exactly, without any exaggeration, upon the course of the Murus Ussu, or upper waters of the great river Yang-tse-Kiang. Nevertheless, the conclusions adopted in Calcutta make this river to be the Yalung, one of the great affluents of the Yang-tse-Kiang.

After some little discussion of a rather desultory nature, — in the course of which Mr. Gordon, an engineer who has travelled extensively in India, asserted that the country on the Bacco, where about six hundred inches of rain fall in a year, was the rainiest in the world, — Mr. Saunders described the first general census of India, which was taken on Feb. 17, 1881. The entire population enumerated was 253,891,821, occupying an area of 1,382,624 square miles. He then compared various parts of this large population with that of other countries chiefly European, and described the Indian house and its contents. This census, which is embodied in twenty folio volumes,

contains reports under the following heads: area of population; movement of population; religious classification; proportion of sexes and religious divisions; condition of population; condition and age of population by religion and province; birthplaces, insanity, deaf-mutes, occupations, languages, education, blind people, lepers, castes. The reports in general are not merely a dry record of figures; but they abound with information of a most interesting character, concerning this grand division of the population of the world, which stands second only in number to its still vaster neighbor, the empire of China. It may be useful to add that an abstract of this census may be obtained in three volumes.

The president of the section, Sir J. Henry Lefroy, spoke of the value of the census, and enlarged upon the fact that it showed that there were nearly two million native Christians in India. In answer to a question, Mr. Saunders said that of this large population but 89,000 were natives of the United Kingdom.

The next paper was on Mount Roraima in British Guiana, by Mr. E. F. im Thurn, for some time a magistrate there, who proposes to examine the mountain as closely as possible on every side, and to make the ascent, should circumstances permit. He intends, moreover, to examine and collect the flora and fauna of the country, and especially to investigate the condition of the little-known Arecoona Indians in whose district Roraima lies.

In conclusion, the recorder of the section, Prof. E. G. Ravenstein, read an exceedingly suggestive paper on the proper method of teaching young children the rudiments of geography. He said that the time when teachers of geography confined themselves to teaching their pupils a barren list of localities was fortunately past, and the principles first enunciated by Pestalozzi and Fröbel might be said to have taken a fair hold. But still the geographical text-books were far too abundant in nomenclature, as distinct from an exposition of facts or an explanation of phenomena. Elementary geography should teach our children to understand the locality in which they live, to observe, and to think for themselves, instead of accepting the definitions presented to them; to describe, further, their experiences in language of their own, instead of paraphrasing the language made use of by their teachers. This method compelled us to take our children out of the schoolroom, and to bring them to the locality which it was desirable to describe. The lesson which followed would be really an object-lesson, which lessons based on a map or a picture or a model could not be. The children should be encouraged to observe the same phenomenon repeatedly until they have obtained a clear conception of it. The children would then observe the fact under consideration once more, with such help as would be afforded by the teacher's explanation; and to this would succeed a final consideration of the subject, within the schoolroom. The subjects of this elementary study ought to include the surface features of our earth, its vegetation and fauna, and its inhabitants. Atmospheric phenomena, as well as the celestial bodies, in as far as their movements are visible from our earth, should also be included. He would include the elements of geology and of natural science generally, in so far as they would explain geographical phenomena; and, besides, he would seek an opportunity of expounding the principles of political economy and of statistics. The range was, therefore, a wide one. The subjects would differ according to the locality in which the school was placed, as during the earlier stages the children would be limited to subjects coming within their sphere of observation; and only at a more advanced age, when the power of imagination had been developed, would they carry the young mind from things seen to things unseen. Thus a consideration of the St. Lawrence and its turgid tributary, the Ottawa, would carry them in course of time to the great lakes, and to the magnificent forests, which explain the color of the water of the rivers. The various phenomena would not at first be considered systematically, but as occasion arose.

This paper was followed by an interesting discussion; during which it was remarked, that the main difficulty in introducing such a method into the school boards of England was the examination system there in vogue; as it was necessary for teachers, if they wished to retain their places, to cram their pupils for the examination. May not some such vicious system be the cause of the gross ignorance on geographical subjects which prevails in our own country?

Mr. James Glaisher read a report of the committee for promoting the survey of western Palestine. He first gave a brief history of the 'Palestine exploration fund,' which was founded in 1865 with the object in general terms of obtaining from the Holy Land itself whatever facts might be gathered for the elucidation of the Bible. The work was classified as follows: 1. Archeology — including excavations; 2. Manners and customs of the modern inhabitants; 3. Topography; 4. Geology; 5. Natural sciences, botany, zoölogy, etc.

The first work undertaken was the excavation at Jerusalem, which occupied the years 1867–1870, and threw a flood of light upon the ancient city. In 1870–1871 a journey was made through the Desert of the exodus; and in the autumn of 1871 the survey, on the scale of an inch to a mile, of western Palestine, was begun. The work was carried on until 1875, when the party was attacked by the Arabs. In 1877 it was resumed; and in 1880 a map in twenty-six sheets was published, followed by a reduction of it on one-third scale in 1882.

In 1882 the survey was extended to the east of the Jordan, but owing to the opposition of the natives was abandoned after only about five hundred square miles had been surveyed. The society is now waiting for the Sultan's firman, without which Mr. Glaisher stated no alien is allowed to remain more than one month in the country, to go there with a camera, or to take away the smallest specimen. He then gave a short account of the results of the geological survey conducted by Professor Hull last winter, a full account of which is now in press.

Dr. J. B. Hurlbert said that by comparing the climates of different portions of the two hemispheres, — western coasts with western, eastern with eastern, and interior divisions with interior, — it was found that vast areas in the new world possessed soils and climates similar to corresponding regions of the old. With regard to the coasts, this was due to the oceanic currents. As to interiors, they had warmer summers and colder winters than oceanic regions; and in the central part of North America, between the parallels of 30° and 50° north latitude, there was but little rain in summer, and much snow in winter. This summer drought was due not to the Rocky Mountains, as many had supposed, but to the prevalence of southwest winds. The operation of these winds was described in detail, and it was asserted that trees could not be induced to grow in that arid waste, and that the prairie once broken up could not be reset. The reverse of all this was true of the interior of Canada. He closed by remarking that climates have as powerful an effect upon the human race as upon vegetables; and that, therefore, the people of this region of great summer drought would in time become like the Bedouin Arabs; while Canada would be the future great power on the continent.

Dr. Hurlbert then read a paper on some peculiar storms. He began by saying that he did not believe in the existence of cyclones, although he admitted the existence of whirlwinds in the West Indies. But he thought that the hurricanes which swept our eastern coasts were due to a warm current of air, which, starting from the Gulf of Mexico, proceeded in a northerly and easterly direction, and, meeting with a cold atmosphere, condensed. Into the vacuum thus formed, air poured from every side, and the storm swept on with ever-increasing violence.

Dr. Ball said that he thought that Dr. Asa Gray would hardly agree with the learned gentleman's deductions with regard to the future of vegetation in the region of summer drought, and reminded him that it often rained there when least expected, and hinted that averages of rainfall, etc., were likely to be misleading. He also asked him some questions as to the climate of the coast of California, to which no satisfactory explanation could be given.

Mr. Trelawney Saunders then severely criticised the unscientific method pursued by the Dominion survey, borrowed from that of the United States survey, which had been devised in times of geodetic darkness; and he advised a method of division of the land by meridians and parallels, which was shown (the next day) by Mr. Leslie Russell of the Dominion survey to be precisely the method pursued by that survey. As to Mr. Saunders's criticisms on the lack of orographic information furnished by the maps of the survey, Mr. Russell replied that the differences in elevation were so slight in the region now being surveyed, that it was impossible to show them by any ordinary means; and that, besides, it was necessary that the territory should be laid out into sections, townships, etc., as soon as possible, that settlers might go there and take up land without fear of future litigation as to boundaries and titles.

On the fourth day Lieut. P. H. Ray, U.S.A., after describing the objects of the circumpolar expeditions, gave an account of the explorations and observations undertaken by him at Point Barrow, Alaska. He said that the ground never thawed to a greater depth than twelve inches; and that two years' careful observation had satisfied him that there is no open polar sea, from the fact that the temperature of the sea-water is unvarying from the time the sea closes in October until it opens in July, which could not well be the case if there were a large body of warm water lying around the pole. Besides, the atmospheric conditions were found to be such as would not exist near a large body of open water. In addition, all discoverers had noticed, that, although a current runs *to* the north, nevertheless the sea is filled with old ice, which he thought came *from* the north, and this could not happen if there is an open polar sea. In concluding he said, that, in laying out the work for the circumpolar expeditions, the magnetic pole had been neglected, which was a great mistake; and he declared that he would willingly go there himself.

The president of the section, in introducing Lieut. Greely, said that his party had helped to solve one of the most difficult geographical problems of the day, and that Lieut. Lockwood had reached the farthest north; that they had furnished data for determining the compression of the polar axis, by observations nearer the pole than any hitherto made; and that they had brought home the pendulum used, that it might be corrected at Washington. He thought that nothing in the annals of scientific heroism exceeded the devotion of those hungry men in sticking to that ponderous piece of metal. Lieut. Greely's paper descriptive of the work of the expedition has been extensively printed; and there is no need of mentioning here more than a few points which, indeed, were supplementary to the paper itself. He said that at Fort Conger the ground thawed to a much greater depth than at Point Barrow, namely, between twenty-nine and thirty-four inches; and that with regard to an open polar sea he believed in the existence of an open, but not necessarily navigable, sea in that direction. He said that he had only been at his station a short time when it struck him that he could tell whether the tide was flowing or ebbing, by the temperature of the water; and by observations he found that when the tide came from the north the water was warmer than when it came from the south. The tide travelled with great velocity; and most perfect observations had been made at different points, in many cases simultaneously, which would be published in due season.

Capt. Bedford Pim, in offering his congratulations to the explorers upon their safe return, said that he was glad that Lieut. Greely agreed with him as to the existence of a *polynia* in the vicinity of the pole, and he hoped that Lieut. Ray would be brought to their way of thinking.

It seemed to be the opinion of all the speakers, that arctic exploration should be continued, and that it was especially important that the magnetic pole (of

which Capt. Pim declared no one knows the position) should be visited, and a large number of accurate observations there taken.

A lunch was given to the two lieutenants in the afternoon, but nothing was then said of geographical importance.

Mr. R. G. Haliburton said that he considered the saga of Eric the Red, describing the voyage of his son Leif to Vinland, a poetic version of Bjarne's voyage reversed. Eric, driven from Norway, and afterwards from Iceland, discovered a dreary country, which he called Greenland, avowedly to attract emigrants thither. Subsequently the land sighted by Bjarne, and visited and colonized by Eric's family, was called by them, evidently for the same object, *Vinland the Good*. The length of the shortest day, the presence of Eskimos, the Norse maps, and geographical notices, all show that Vinland could not have been south of the north-western part of Newfoundland.

Mr. Haliburton also said that recently discovered Portuguese documents prove that the next oldest colony in America was *Terra nova*, embracing Labrador, Newfoundland, and Nova Scotia, which was explored by the Corte Reals in 1500–1502; and that commissions were regularly issued to them as governors up to 1579. In 1521 a patent was issued to Fagundes of all the lands between the Spanish colonies and 'the land of the Corte Reals.' He had recently discovered, while in the Azores, that two Portuguese colonies sailed thence to Cape Breton in 1521 and 1567, probably to St. Peters and Ingonische. The Spaniards, who annexed Portugal to Spain in 1580, sent a colony to Spanish Harbour (Sydney) between 1580 and 1597. He added that Cape Race (*Cabo raso* —'bare cape'), the Bay of Fundy (*Fonda*—'deep'), and other Portuguese names, still tell of this 'lost colony.'

The Rev. Abbé Laflamme then said, that the province of Quebec may be divided into two hydrographic basins, —that of the St. Lawrence, and that formed by the collection of lakes which fed the rivers flowing into Hudson's Bay. The name of only one of these lakes was known, —lake Mistassimi. It was certain, however, that there were many others of great size in its vicinity and on the peninsula of Labrador. He declared that all the maps hitherto published of lake Mistassimi were inexact. One thing only was certain, and that was, that it was larger than lake Ontario.

Professor W. Boyd Dawkins maintained that the former connection of North America with Greenland, Iceland, and north-western Europe is most conclusively proved by the distribution of the fossil plants and animals in the eocene and miocene ages. The tract of comparatively shallow water ranging from Greenland past Iceland to the Faroës and northern Scotland, and which isolates the deep waters of the Arctic sea from the depths of the Atlantic, formed the bridge across which the migration took place, the four-hundred-fathom line representing approximately the line of the ancient shores. The barrier became submerged towards the close of the miocene age; and then, for the first time, the Arctic waters united with the Atlantic, and arctic shells gradually found their way southwards into the area of the British isles.

Mr. J. S. O'Halloran then presented a memorandum with regard to Winnecke's exploration of central Australia, with notes on the employment of camels, and some extracts from his journals. The reference to camels reminded Mr. Torrance that they were formerly employed in British Columbia, but that the smell of the beasts so terrified horses that the government ordered their use to be discontinued.

The president of the section then made some remarks about the poor attendance at some of the meetings, — at one time there were but four persons present, besides the officers and reporters, — which he attributed to the unfortunate position of the building in which the meetings were held; and the section was then adjourned.

PROCEEDINGS OF THE SECTION OF ECONOMIC SCIENCE AND STATISTICS.

This section has been in existence almost from the foundation of the British association, having been organized as a section of statistics in 1833: economics were added in 1856. The range of topics considered has been very wide, and has included such topics as population, mortality, emigration, labor, crime, punishments, debt, wealth, trade, coinage, banking, insurance, poor-laws, schools, libraries, sanitary regulations, water-supply, pollutions of rivers, forestry, agriculture, stock-raising, imports and exports.

The section assembled at eleven o'clock on Thursday, in Synod hall, several blocks distant from McGill college, where most of the sections were located. Nevertheless, about 140 persons were present to listen to the address of the sectional president, Sir Richard Temple, of London, upon the general statistics of the British empire.[1] It was noticeable that the applause occurred when reference was made to the superiority of Great Britain, and but once when comparisons showed the United States to be superior to the empire. A vote of thanks was proposed by Prof. J. Clark Murray, of Montreal, and was supported by Mr. Edward Atkinson of Boston, who highly complimented Sir Richard Temple for his efforts in founding the school of British economical science. Professor Murray thought this section would be more interesting to Canada than any other; because, 1° it was not so abstruse, and 2° it treated of matters of vital importance to Canadian voters. He hoped soon to see a chair of economic science in McGill college.

Sir Richard Temple said he would accord the place of honor to the United States, and called on Mr. Atkinson to read the first paper, entitled 'What makes the rate of wages.' Mr. Atkinson said that the argument of Mr. Henry George in his 'Progress and poverty,' that the rich are growing richer, and the poor

[1] The address is printed in abstract in *Science* of Sept. 5, p. 214.

becoming poorer, as a whole, was not conclusive, and that the extraordinary circulation of the book in many languages showed how all-important was the question at this time. He therefore suggested, in reply, that, as it is generally conceded that somewhere and always there is enough and to spare, the question is only one of distribution, not of production. And yet distribution he held to be subsidiary to production, claiming that at no time should more be distributed than was produced in that period. That distribution is to 1° taxes, 2° profit, 3° labor, — the last receiving all that the others leave, and being measured by wages. The true wage which is due to the laborer is food, fuel, shelter, and other means of subsistence. The vast majority of mankind are wage-receivers. What determines the rate of their wages in terms of money? *High rates of wages are the natural and necessary result of low cost of production.* Especially is this so in the United States, where the people are homogeneous, means of intercommunication ample, and where there is no artificial obstruction to prevent commerce. Wages are therefore the consequence and remainder over after capital has received its profits. This remainder has been constantly increasing. This he illustrated by elaborate statistics, compiled from the books of two New England cotton-factories. The profits declined, having been 2.40 cents per yard in 1830; 1.18 in 1840; 1.11 in 1850; .69 in 1860; .66 in 1870; .48 in 1880; .43 in 1883; and .41 in 1884. The average annual wage per operator had increased at the above dates as follows: $164, $175, $190, $197, $240, $259, $287, and $290.[1] Profits and wages together showed a constant increase due to increased efficiency and subdivision of labor, improved machinery, and a consequent lower cost of production. Capital alone made this possible. Vanderbilt was pronounced the greatest communist in the United States, in that, for every cent he saves from his railroads, he saves a dollar to the masses in the cost of transportation, and thus aids a low cost of production, which, in turn, gives a high rate of wages. Mr. Atkinson incidentally pointed out, as against the Malthusian theory, that as yet a field ten miles square would hold the population of the earth, while one twenty miles square would seat every person; and that, but for the interdependence of nations, an enormous part of the products of our soil would rot as valueless. It is our duty to show the masses how, in the distribution, each may get his share; or, as Gladstone has said, to weave the web of concord among the nations.

The paper was discussed at length by Sir Richard Temple; J. B. Martin of London; Prof. H. S. Foxwell of St. John's college, Cambridge; Mr. Swire Smith, of the Royal commission on education, Lowfield, England; David Chadwick of London; and Cornelius Walford, the secretary of the Geographical society, London. The general tenor of discussion was highly complimentary to the essayist. Mr. Martin thought labor and capital unavoidably in opposition, not to say antagonistic; and that the rate of wages would be determined by the margin existing between the cost of wages and what the laborer is willing to confine himself to for a living. That margin which so attracts emigrants he found excessive on this continent, and was totally at a loss to explain why it required ten cents to get his boots blacked in Montreal.

Professor Foxwell said that in Ricardo's time capital was the starting-point for discussion; now it is labor. Gen. F. A. Walker has done much, by his political economy, to influence thought in England. In the distribution in question, every thing depends upon the *equality of the bargainers.* As laborers have become wiser, they have bargained for a better distribution. In the United States this has been potent. The diffusion of property as a reserve is a very important aid to bargainers. England much needs to educate its laborers, and secure a diffusion of property. Monopolies he had regarded with distrust, but is coming to think them desirable: they must, however, be under some public control and restraint. He pointed out that the rise in factory wages had been coincident with the rise of labor-unions, and doubted whether capitalists voluntarily raised the wages. Capital invested in factories was doubtless receiving a lower percentage of profit, but interest is also lower. Mr. Smith could see, in the facts presented, only Adam Smith's law of supply and demand regulating rate of wages. Mr. Chadwick demurred from the Smith doctrine. Disturbing elements have come in. By combination English laborers have forced higher wages, and the hours of labor per week from sixty in 1849 to fifty-six and one-half in 1884. Capitalists have always known their power: the laborers, only recently. Germans, French, and Swiss work sixty hours, solely because they do not realize their power, and combine for a reduction. Mr. Atkinson admitted that character, in the last analysis, makes the rate of wages. He thought, that, although legislation had attempted in Massachusetts to regulate hours of labor, the changes cited have come about naturally, and regardless thereof.

Three papers on savings banks followed. Mr. W. A. Douglass, of the Freehold and savings society of Toronto, gave the history and described the management of loan and savings companies in Ontario. Starting in 1855, the number has reached 73, with assets of $79,500,008. Seven per cent is obtained in Ontario, and nine per cent in Manitoba, on good mortgages. Since 1874 the companies have obtained some money from England, the amount so handled amounting to $25,679,803. Mr. Stephen Bourne remarked upon the opportunity thus presented for England to invest surplus funds, and of her duty to thus aid her colonies. Mr. Atkinson spoke of the 800,000 accounts averaging $300 each, in Massachusetts savings banks, and of the accumulations made by Irish laborers Mr. J. Cunningham Stewart, of Ottawa, sent a paper upon the history and progress of post-office savings banks, which contained the statistics of the subject from official sources. After sixteen years' growth, Ontario has 57,296 depositors, and Quebec 9,386. The deposits amount to $13,-245,000, one-half of which is held in Montreal and

[1] All figures are reduced to gold basis.

Quebec city. Mr. Thomas D. Tims also sent a paper on dominion savings banks. Vice-president Martin remarked upon these papers, deprecating the tendency of people to avoid making their own investments by intrusting them too much to such institutions.

A paper on Irish emigration was read in behalf of Mr. James A. Tuke, the founder of Tuke's emigration bureau. This paper graphically pictured the abject condition in Connaught and many Irish counties. Some 200,000 families, or 1,000,000 persons, occupy small holdings never taxed as worth over $20 to $50, and consisting of from one to ten acres of bog-land. This at best yields not over nine months' subsistence, leaving three months' dependence on charity. The least evil for remedying this state of affairs was found in emigration to America. At an expenditure of $68,500 he has aided 9,482 to seek a better home in the new world. Of this money, 220,000 was from the government, and the remainder private gifts. Over seventy-seven per cent were the young and healthy, but too poor to obtain transportation money for themselves. Once located, however, they have been industrious, and at once set to work to send back savings to their relatives, thus enabling them also to emigrate. Not less than $25,000 was so returned to Ireland in 1882 and 1883, one shop-keeper having cashed $1,000 of such drafts. Of the counties furnishing emigrants, seventeen per cent of the population was removed. The people were located in 165 different places, 148 in the United States, and 17 in Canada. Less than five per cent had ever uttered a complaint as to their new condition. The paper was discussed by Mr. John Lowe, Department of agriculture at Ottawa, and by Major P. G. Craigie of London, both of whom had observed the good effects of Mr. Tuke's work. The latter said, 'The Irishman will succeed best out of Ireland.'

Mr. W. Westgarth, president of the Melbourne chamber of commerce, read a paper on the British Empire in North America and Australia. He made elaborate comparisons between Canada and Australia, and furnished valuable facts, especially concerning the latter. He admitted that a drought had swept away ten million sheep, but said they had sixty-six million left. The dominion exports of 1882 were valued at $97,671,000; the Australian, at $255,000,000, chiefly consisting of wool and gold. Victoria has already exported £210,000,000 sterling in gold. The dominion has 9,000 miles of railway; Australia, 7,000 miles. Dominion annual revenue, $36,000,000; Australian, $110,000,000. Dominion debt, $153,661,000; Australian, $496,250,000. He urged the need of closer ties between Great Britain and her colonies.

On Friday, Vice-president Martin read a paper on media of exchange, or notes upon the precious metals, speaking of 1° the metals, 2° coin, 3° bank-notes, 4° instruments of credit. The discussion was participated in by Mr. Chadwick; Mr. Atkinson; Mr. Sidney Fisher, M.P.; Mr. Stephen Bourne of Wallington, Surrey; Hon. C. W. Fremantle, Master of the royal mint, London; and Dr. James Edmunds of London. The latter spoke of small bank-notes as a most serious media of infection, the germs of cholera, small-pox, scarlet-fever, etc., being retained therein. Coin may be disinfected by heat. The paper and the discussion included such topics as the advantages and disadvantages of coin, the supposed gold depreciation since the opening of American and Australian mines, the dangers from inconvertible notes, the improbability of changes in the English sovereign, the proper method of meeting the expense of converting bullion into coin, the blessings of a good banking-system, with allusions to those of the United States, Russia, and other nations. Dr. Edmunds regarded the value of gold as dependent on so many variables, that its actual value cannot be ascertained. Mr. Atkinson thought gold had lost some of its purchasing power, and Mr. Martin thought it had steadily increased.

Mr. Michael G. Mulhall of London, author of the Dictionary of statistics, read a paper upon the debts of nations. The debts of the leading nations in 1884 he reported in millions of dollars, as follows: France, 4,975; Great Britain, 3,780; Russia, 2,775; Austria, 2,540; Italy, 2,190; Germany, 1,670; Spain, 1,650; United States, 1,525; Spanish America, 975; India, 800; Turkey, 740; Australia, 580; Egypt, 565; Portugal, 535; Holland, 420; Belgium, 390; Japan, 335; Canada, 190; Roumania, 135; South Africa, 115; Norway and Sweden, 100; Greece, 90; Denmark, 60; Servia, 20. Grand total, $27,155,000,000. From 1848 to 1870, the annual increase averaged $99,000,000; from 1870 to 1884, $115,000,000. The increase, however, has not kept pace with the increase of wealth. Of existing debts, sixty per cent stand for war expenditure, and forty per cent for improvements; but of debts incurred since 1848, fifty-five per cent was for peace, and forty-five per cent for war. The paper was discussed by Mr. Walford, Dr. Edmunds, and Mr. Atkinson. The contracting of war-debts was severely denounced; and, although the essayist regarded debt as a convenient investment, as no injury to the working-classes, and as not to be feared, the tenor of criticism was decidedly adverse to these ideas. Mr. Atkinson especially criticised the bond-holder, if not also a producer, as a burden upon society. To ascertain what burden a national debt is, we should consider, not population, not accumulated wealth even, but the *annual national product*. Burden is in ratio to net savings. A people which cannot save any thing from the current product is unbearably burdened by a public debt. How many laboring men in Europe, he asked, can save twelve pounds per year? The U. S. debt, he said, had been reduced from eighty-eight dollars per capita to twenty-five dollars per capita. He claimed that it reached $3,000,000,000 at the close of the war, although the official debt statements never showed so much. There were outstanding and unaudited liabilities which made the difference. Before these had been adjusted, the debt had been reduced by a similar amount. He prophesied that the progress of this continent would compel Europe to disband her armies, and pay off her debts, in order to get upon a competing footing.

A paper sent by Mr. J. McLennan, upon Canadian

finances, was discussed by Mr. Stephen Bourne, Mr. Hale of Montreal, Mr. Atkinson, Mr. Thomas White, and others. Some criticisms of Canadian tariff-laws and the sale of public lands were made by Englishmen, and replied to with spirit by Canadians. The latter usually professed to be free-traders, but defended the tariff, as required by very peculiar circumstances, such as its proximity to the United States. The American theory of the subdivision of public lands was explained by Mr. Atkinson, who also illustrated public subsidizing of railroad schemes by the history of the Hoosac tunnel. The interest on this debt would alone pay for transporting the bread of New England from the far west to Boston.

Major P. G. Craigie, secretary of the Central chamber of agriculture, read a paper on agricultural production with special reference to the supply of meat. With an increase in the population of Great Britain since 1868 of 16%, there has been but 4% increase of cultivated area, 11% increase in cattle, and 24% decrease in sheep. Consequently the importation of meat has grown from 100,000 tons in 1868, to 316,000 tons in 1876, and to 450,000 tons in 1883. The total consumption in 1868 he placed at 1,374,000 tons, or 100 pounds per capita; in 1883, at 1,774,000 tons, or 112 pounds per capita. The paper was discussed by Professor William H. Brewer of Yale college, Mr. Atkinson, and others. Mr. Atkinson said he had tried in vain to ascertain the consumption of meat per capita in the United States. A year's supply of meat and flour had been assumed to include three hundred pounds of the former and one barrel of the latter. To move this year's supply from the west, its place of production, to Massachusetts, costs but one day's labor, $1.25. He also spoke of the negro rations — three and a half pounds of bacon and one peck of corn meal — as producing a given amount of force at the smallest cost of any diet among any people of the earth, the cost being but seven cents per day. The reason is that the 'hog and hominy' are peculiarly adapted to each other for ready and perfect digestion.

Professor John Prince Sheldon and Prof. W. Fream, of the Downton college of agriculture in Salisbury, read interesting papers upon British and Canadian agriculture, as did Prof. W. Brown upon Canadian agriculture. Papers by Gen. M. Laurie of London, John Carnegie, M.P., of Peterborough, Ont., and Sydney Fisher, M.P., had been prepared upon the agriculture of Nova Scotia, Ontario, and Quebec; but there was not time to present them, the section having been in continuous session for six hours. Propositions to prevent the entrance of cattle-disease from the U. S. were repeatedly made and favorably received. It was shown that the acreage in Great Britain devoted to wheat and corn is constantly decreasing, and that to grass and pasturage increasing. Farm-rents are declining, and must continue to decline. Railway charges there are exorbitant. Wheat can be brought across the ocean cheaper than from some counties by rail. Several gentlemen discussed the papers. Peter Price, an English landowner, uttered his astonishment at what he had seen here: his best tenants are leaving him, and he cannot rebuke them. His estate of three hundred and fifty acres is going into pasture, and he cannot get enough out of it to pay taxes. The thrift of Canadian agriculturists and the embarrassments of Great Britain were brought out in the most striking manner, much to the satisfaction of Canadians, the amazement of the British, and the amusement of Americans.

On Monday a paper by Mr. Stephen Bourne was read upon the interdependence of the several portions of the British Empire. After presenting some statistics, Mr. Bourne entered upon an exhortation to the colonies to combine with the mother country in refusing to buy from nations which enforce protection. 'We should,' said he, 'teach the nations that we have a world of our own.' He would not answer protection with protection, but with absolute cessation of trade with those who are not 'fair-traders.' Sir Richard Temple suggested that England could not, so far as now known, get its long-staple cotton anywhere but from the United States, a high-tariff nation. Mr. Chadwick denounced the proposition, and said the author dare not make it, were the section in session in the British isles. 'This,' he said, 'would starve half our people and half our cattle' The president felt called upon to defend freedom of speech, although not agreeing with the speaker. Amid much excitement the Canadians rushed to the defence of their tariff, and openly declared that if they must choose between such an alliance with Great Britain and one with the United States, they had much to gain and little to lose by choosing the latter. Mr. Atkinson indicated the satisfaction which the United States might feel at such an arrangement. It would keep her products at home, glut the market, make labor much cheaper, and so reduce the cost of manufactured fabrics. She would then be able to compete in the world's markets, as she cannot now with English manufacturers! Mr. Thomas G. Haliburton said the foreign trade of England was decreasing, and that at the present rate of decrease but twenty years were needed to terminate it: hence the need of wise dealings with the colonies and foreign nations. Mr. Roswell Fisher of Montreal said such a policy would not do for the dominion. 'We Canadians exist here on the sufferance of the United States' [loud shouts of No, No!]. Should England retaliate upon the United States, it could crush Canada with a prohibitory tariff. But politically and socially Canada was nearer the latter than the former. No number of ocean telegraphs and swift steamers can destroy American unity [great excitement]. Sir Francis Hincks, a Canadian politician of fifty years' experience, being loudly called for, said, 'Let well alone.' Canada does not want representation in the British parliament and in army tax-lists, nor is she interested in her Majesty's foreign policy. He emphasized American friendliness, and the necessity of meeting the tariff of the United States wisely.

Mr. R. W. Cooke Taylor, inspector of factories, Treston, Eng., read a paper on factory acts. These are for the protection of women and children. Mrs.

King and Mrs. Hallett discussed the paper, expressing dissatisfaction with the act, and saying women could take care of themselves. Mr. Robert C. Adams of Montreal read a paper on the phosphate industry of Canada. In 1883 it amounted to 17,500 tons. Phosphate lands have sold as high as $1,250 per acre. Mr. Hughes, Mr. Martin, and Sir Richard Temple discussed the paper. A valuable paper on the fisheries of Canada, by Mr. L. Z. Joncas, was read by Mr. Thomas White, M.P.[1] The paper was discussed by Mr. Cornelius Walford and Mr. C. W. Smiley of the U. S. fish-commission. Several forestry papers closed the sitting, — Professor Brown of Ontario, on the application of scientific and practical arboriculture to Canada; Mr. J. P. Hughes, on the necessity of forest preservation; Mr. A. T. Drummond of Montreal, on the distribution of Canadian trees; and Mr. F. B. Hough, on the future policy of the forest management of the United States. Mr. Walford remarked that forest culture in England pays four per cent profit, and in the United States seven per cent. Mr. Caruthers of the British museum also made remarks. The anthropometric committee presented a printed report, including observations on eyesight by Mr. C. Roberts. This report contained valuable tables. On Tuesday Mr. Cornelius Walford spoke upon land and water communication. Mr. E. Wragge and Alexander McDougall presented a joint paper upon the same topic. A paper by Emile de Laveleye, upon land laws, was read by the secretary. Miss Maria Rye, Mrs. Burt, and Mrs. Joyce each read a paper on female emigration. C. Le Neve Foster read a paper on the relative dangers of coal and metal mining. Many of the papers were presented by the authors in printed form, and printed abstracts of many others were circulated.

PROCEEDINGS OF THE SECTION OF MECHANICAL SCIENCE.

THE mechanical science section of the British Association appears to be in a prosperous condition, as was intimated, indeed, in the opening paragraph of the address of its president, Sir Frederick Bramwell: this is due, no doubt, to the fact that its scope is much wider than its name implies. The president's address was instructive as well as witty; it was in the form of an apology for the practical character of the section, and exhibited in detail the interdependence between it and the others, showing it to be complementary to them; but the distinguished author did not fail to scatter valuable suggestions throughout, and to indicate some lines of past and future progress. The address, however, contains no carefully digested summary of engineering progress for the past year or up to the present time; and though many valuable papers, prepared by request, summarize progress in particular directions, the general scientific reader must seriously regret the fact. The various criticisms upon the hampering action of the government toward engineering enterprises, such as electric lightning, the telephone, the Channel tunnel, brought out the strong feeling of the English members, that the government should confine itself to governing. The courtesy shown the president in the delivery and acceptance of his address was a pleasant feature: the presidents of the association and of the physical section, as well as the sectional vice-presidents and secretaries, were upon the platform, and the former moved a vote of thanks. In doing so Lord Rayleigh commented upon the Channel tunnel and other government interference; and was followed by Vice-president Thurston, who seconded the motion, expressing the American sympathy with the obituary notice of William Siemens, and cordially inviting the members to take part in Section D at Philadelphia.

The multiplication of section officers is to be noted; there being no less than eight vice-presidents, four secretaries, and a large sectional committee, among whom appear the following gentlemen from the United States: Messrs. Coon, Emery, Hoadley, Leavitt, and Woodbury, and Professors Barker, Bell, Rogers, and Webb.

Many of the papers read were 'progress papers,' containing masses of detail of little interest to the general reader. The importance and extent of some of them render it a matter of regret that they were not generally in print, and that they were presented in so hurried a manner. In many cases, an abstract setting forth the main features of the paper, and comparing and emphasizing the main facts, with illustrations and graphical representations of results, would be far more effective when time is limited; and though such abstracts involve labor, they are of great permanent value to the paper.

The papers were classified as follows: First session, civil engineering; second, mechanical engineering; third, electrical papers; fourth, miscellaneous. Some of them were prepared by request to describe American practice, and some attempt was made to have comparative English papers.

Mr. B. Baker described the Forth Bridge. The expected cost of this enormous structure is £1,600,000. Excluding the half-mile of approach viaducts, the bridge will be over a mile long, consisting of three cantilevers, each over 1,500 feet long, and two connecting trusses of 350 feet each. Cantilevers stand on the two (Queensferry and Fife) banks, and one rests on the only island (Inchgarvie) midway; they are to be 340 feet high by 130 wide at their centres, tapering to 40 feet by 35 at their ends, where they sustain the ends of the connecting trusses. The material is steel, to be put together (after the English fashion) by riveting as each plate is placed in position. Work is now being done on the piers, and some steel is ready for the superstructure; nearly 50,000 tons will be required. The bridge leaves two arched water-ways of 1,700 feet, with 150 feet clear central height at high water, and a half arch at each side. It was commenced about twenty months ago, and no difficulties are anticipated. Fourteen vessels, seventy-two steam and other cranes, and twenty-eight steam-engines, with numerous special machines,

[1] This paper will be published in the U. S. fish-commission bulletin.

are used in its construction. Each of the three main piers consists of four masonry columns, 70 feet in diameter, upon rock or hard clay bottom, centred at the corners of a rectangle 270′ × 120′. The deepest foundation will be 70′ below low water, which makes it 110′ high, allowing 20′ for the tide, and 20′ more above high water. Add to this 340′, and we have 450′ total height. There need only be added a central observing-tower or flagstaff to make it the highest structure in the world. Attention is called to the difference between English and other contractors: the former are "not much accustomed to pneumatic appliances, other than an ordinary diving-dress, and rarely resort to them." No use has been made of pneumatic apparatus already provided, but for the deepest piers compressed air will doubtless have to be used. The compression members of the bridge are tubes formed of bent steel plates riveted together. Compression joints are planed to fit, and forced together before riveting; and holes for rivets are drilled, not punched. The tension members are box-girders riveted up. A large number of experiments have been made to settle doubtful points, notably as to wind pressure, regarding which reliable data were wanting: in so large a bridge, the weight of trains is of little importance as compared with that of the structure and the pressure of the wind. As it must be a problem of some difficulty, to join the members of such a structure in a substantial and artistic manner, it is to be regretted that the details of the joints were not shown, and that no judgment can be formed of their merits. Altogether, though the proportions of the structure may not be pleasing, they cannot fail to be imposing; and the truss principle will hereby, as regards possible span, be placed for the first time abreast of the suspension cable.

The discussion participated in by Messrs. Hannaford, Leavitt, Emery, and Webb, brought out the relative costs per foot — £200, £160, and £75 — for this, the Victoria, and the International bridges; the latter two having only a single track. Steel was stated to be cheaper than iron; and many questions were asked as to the constitution, properties, etc., of the steel used, to which there was no time for suitable reply.

A paper on the Severn Tunnel Railway, by J. C. Hawkshaw, naturally followed. This tunnel, commenced in 1873, and nearly completed, is four and one-third miles long, and will save over two miles of ferriage. It is a twenty-five-feet hole, lined with vitrified bricks made from the excavated material, and laid in Portland cement. It passes principally through marl and coal, full of fissures. At the lowest point its roof is forty-five feet below the river-bottom, over which flows the water sixty feet plus a tide of thirty-six feet. To reach this depth we have slopes of over one per one hundred. Much trouble has been caused by water. In one instance the wells for miles round were dried, and a river nearly disappeared; at another, a sixteen-foot hole broke through the river-bottom; in fact, there has been a succession of floodings and cavings-in, and the work is a monument of perseverance. Pumps have been added until there are now eighteen, with a capacity of forty-six thousand gallons per minute. There have also been radical alterations of the original plan. When Sir John Hawkshaw was appointed engineer in 1879, he lowered the whole tunnel fifteen feet, necessitating a new driftway. The driftways were commenced from several shafts; and there are now twelve shafts about fifteen feet diameter and from seventy to two hundred and twenty feet deep. Electric lights are now used, and compressed air has been employed for drilling and ventilation, though now air is forced through the entire distance by an eighteen-feet-diameter fan. The cost of the work is not known, and it is difficult to believe that much time and money might not have been saved by employing, from the start, a properly planned pneumatic process; indeed, the extra fifteen feet depth of the tunnel below the river-bed would seem to be a permanent disadvantage which might thus have been avoided.

Three railway papers followed. The first, by W. K. Muir, on single-track railways, was a condensed statement of the construction and method of operating a railway in America, where but a single track can be afforded. General plans of stations and crossings were given, and an infinite number of details alluded to as necessary to safety, comfort, and economy. The numbering of the hours from one to twenty-four was advocated. Much was said upon modes of signalling, and an improved signal-lamp described. It was claimed that white and red signals were sufficient, it being safer to exclude green. In the discussion it appeared that an economy is effected by strengthening cars so that they can be loaded full: formerly grain was carried two and a half feet deep, now four is customary. The American method of making up a time-card was explained, where the trains are represented by threads stretched over a board ruled one way for time, and the other way for distance. Mr. Preece spoke of the safety on railways: the safest place in England is supposed to be a first-class carriage between London and Edinburgh. The president advocated running trains by telegraph from a central station, there being absolute safety with but one train on the track at a time. This caused reference to be made to a Paris incident, where an unusually long train, going round a loop, ran into its own tail. Sir James Douglass spoke of the excellency of American head-lights, and advocated a mechanical signal-lamp to save time; to which was replied that the American train-man was quick, and a wiggle or two of his lamp was enough.

Mr. J. H. Wilson's paper on American permanent way referred more to the construction of the line, forming therefore a complement to the last. The qualities of a perfect track are good surface and drainage, and straight or truly curved track, of accurate width, well fastened and with tight joints. American rails rest with broad flanges on wooden ties; while English rails are reversible, and rest in iron chairs, so that ties can be placed far apart. Wooden ties, being plenty here, should be laid only two feet apart. Engines weigh from forty to over sixty tons. Detailed specifications for rails, etc., ac-

cording to the best practice, are given: ninety per cent of the rails must be thirty feet long, and a test piece must be furnished from each charge of steel. These specifications, and the rules by which rails are temporarily or permanently rejected, are elaborate and exact, and must result in a uniformity of quality and composition leaving little to be desired. In track-laying, the rails must meet within $\frac{1}{16}$ inch in summer, and $\frac{4}{16}$ inch in winter. Considerable space is devoted to ties, ballast, switches, frogs, crossings; and attention is called to the importance of the block-system, Westinghouse air-brake, interlocking switches, etc.

Mr. Vernon Smith's paper on the Canadian Pacific railway described the construction of the same, and pointed out its advantages. British Columbia joined the confederation in 1871 on a pledge that such a railway should be completed by 1881, afterward extended to 1891, seven hundred miles of it to be built by the government. The working season is about five months, and all supplies and men must be brought a great distance. Three gaps, of about four hundred miles each, now remaining, will be completed by next year. No existing railway has been built so quickly: every thing is completed at once, and in the most systematic manner; the longest delay has been one of three hours waiting for material. The road has been run at the rate of three or four miles per day, the maximum day's work being six miles and three-eighths. Different modes of excavating were compared; nine thousand Chinese work on the Pacific end; Italians and Swedes excavate twenty-five cubic yards per man per day, with shovels, etc.; Americans, with scrapers, move sixty to a hundred yards; and an eight to ten horse grading has been tried. The precaution has been taken of raising the embankment to the snow-level. Telegraphic service is established at the same time, which requires an additional corps of a hundred and fifty men. Coal-beds exist at both ends of the line. Crossing the Rocky Mountains requires some grades of a hundred and sixteen feet to the mile; but the pass is three thousand feet lower than those farther south, and the rest of the line has easy grades. A degree of longitude on this line is eight miles shorter than on the Union Pacific, so that the route from England to Japan can be shortened a thousand miles. Reference was made to the proposed railway from the Pacific to Hudson's Bay, which would be eighteen hundred miles shorter, but navigation is good only four months yearly, — a great difficulty also with the Canadian Pacific, unless it seeks a new outlet in Nova Scotia. This paper will appear in the transactions *in extenso*, and will be of great interest in England. Mr. Hannaford remarked that the six and three-eighths miles per day finished road would, however, be received with an incredulous smile.

On Friday eight papers were read on Mechanical engineering, and with true courtesy the visiting American engineers were placed at the head of the list: in marked contrast, however, was the want of tact displayed in the reception of Mr. Hoadley's valuable paper on steam-engineering practice in the United States, which was limited to so short a time as to amount to a virtual non-presentation. It is now in book form, and an abstract of the same may be expected at the Philadelphia meeting of the American association.

Professor Thurston's paper on the theory of the steam-engine was a historical sketch, tracing from the earliest period to the present the progress of the mechanical theory of heat, and the science of thermo-dynamics and its applications, and the completion of the theory by the addition of a theory of avoidable losses. The labors of Rankine and of Clausius were considered as to their influence on the theory of the subject. It was pointed out that Carnot established a number of fundamental principles, and first produced a consistent theory of heat-engines, which was further perfected by Rankine and Clausius. The limitations in applying the thermo-dynamic theory were described, and shown to have been familiar to Watt and to Smeaton, and to have been experimentally examined by Tredgold, Clark, Isherwood, and Hirn, and studied by Cotterill. It was concluded that the history may be divided, as by Hirn, into three periods: 1. Crude theory and incomplete experiment; 2. Perfected thermo-dynamics and systematic experiment; 3. Complete theory and exact experiment directed toward the determination of wastes. Professor Thurston calls the last two periods those of the theory of the ideal and of the real steam-engine, and believes that a working theory of heat-engines will soon be completely constructed. The complete paper will soon be published. In the discussion it was agreed on all sides, that the thing needed to still further accord theory and practice is an experimental engine specially adapted to scientific investigation; and it is to be hoped that some of our American schools will take hold of the matter before it is done elsewhere. Experiments were also referred to, where a copious supply of oil had reduced cylinder condensation in a marked degree.

Mr. E. D. Leavitt, jun., read a paper on pumping-machinery in America, largely statistical in its nature, in which he briefly sketched the most salient features in the development of the pumping-engine in the United States as applied to water-supply for cities and for mining purposes, giving particulars of the pumping-plant in all the principal water-works in North America. He called attention to the important work done in the development of pumping-machinery by the various hydraulic engineers of this country. Attention was called to those recent improvements in pumping-plant which have brought about the present great economy in certain places, most notably those designed by Mr. George H. Corliss, and others by himself. Prominent among these improvements have been compounding, higher steam pressures, and greater ratios of expansion. In conclusion, he drew attention to considerations from an economic standpoint, which decide whether to use a cheap plant with no great economy of fuel, or an expensive one from which great economy may be expected; the deciding point being, whether the extra cost of fuel for the cheaper plant will exceed the

interest on the extra money invested in the more expensive one.

Mr. J. D. Barnett's paper, on the anthracite-burning locomotive of America, showed that the cleanliness of this fuel was forcing it into use, notwithstanding that it requires a much larger grate-surface, and has an evaporating efficiency but three-quarters that of bituminous coal at market prices: however, where the railroad-companies own the mines, the market price is no basis for comparison. The anthracite is also heavier to carry, and burns the fire-boxes out twenty to forty per cent sooner.

Messrs. A. McDonnell and J. A. F. Aspinwall, and W. Stroudley contributed representative papers on English locomotives. The weights of locomotives were given as from twenty-eight to thirty-nine tons,— much less than our own, but capable of great speed, which, however, is now equalled or excelled here. Improvements are rapidly forcing their way into English engines, which are now built in a limited number of classes, with interchangeable parts. Special tools are not used, however, to any extent in their construction, and but little attention is paid to elegance, or to the comfort of the engineer. Inside cylinders are mostly used; and on one road the driving-wheels are in front, on the supposition that they keep the track better.

Mr. D. Joy furnished a paper on his reversing and expansion valve gear. This is an arrangement of levers, etc., by which the valve motion is obtained from the connecting-rod instead of from the shaft. It is advantageously used on many locomotives, and has been applied also to marine engines. It makes the connections much shorter and lighter, and avoids the double eccentric. Many other advantages are also shown.

Mr. J. H. Bartlett's paper on heating buildings by steam from a central source is a most valuable *résumé* of the subject in pamphlet form. It shows, that, prior to 1876, large buildings and even blocks had been heated by steam from a central source; and in many cases steam had been successfully piped long distances. Mr. Holly then suggested the present district plan; and experiments were made which have led to a remarkable development of the system, which were described in detail. Drawings were given of Holly's reducing-valve and regulator, and of his steam-meter; also a plan of the large district in operation in New York city. Estimates for a district of four hundred (also a thousand) dwellings, and two miles of main, during two hundred and forty days, were given; and the relative cost given of the individual-furnace, individual-steam, and district systems, — the latter with four hundred, also a thousand consumers, — was $113, $197, $64, $58. The economy of elevating the burning of coal into a distinct business must be evident to all; and there is no better distributer of heat than steam. To form an idea of the magnitude of the New York company's operations, their plant should be inspected.

On Monday, papers were read by Mr. W. Smith, on the light-house system of Canada; and by Sir J. Douglass, on improvements in coast-signals. These were remarkably well illustrated by nearly one thousand square feet of colored drawings, covering the walls, and referring mainly to the new Eddystone light-house. Among these were Winstanley's (1696-1703, washed away), Rudyerd's (1706-1755, burned), Smeaton's (1755-1882, removed to another site), — all of about the same height; and the new light-house nearly twice the height (one hundred and thirty-three feet to lantern). Another drawing reproduced Smeaton's drawing of his light-house with a wave rising fifty feet above it, and added another immense wave which broke over the lantern in 1881, through which the moon was seen. Canada has nearly six thousand miles of coast, with about five hundred light-stations; and Mr. Smith referred to buoys to be placed below Quebec, with reservoirs of gas capable of maintaining a light for ninety hours. He remarked also, that Canada was doing her best to compete with New York for the carrying trade of the west, by improving her light-house system. Experiments are being made by the British government on coast-signals, some results of which were given. The electric light was found to have almost no fog-penetrating power, so that only by an immense multiplication of candle-power was it made equal to gas or oil in the worst weather. Its cheapness showed forcibly, however, in a statement that 22,000 times the light could now be had for the cost of the candles of Winstanley's house. A heavy wave was instanced as carrying away a three-hundred-pound bell, a hundred and ten feet above high water. There would seem, however, to be no reason why, with a properly shaped rock to deflect it upward, a wave might not rise to an immense height. A new system of lights and fog-signals was explained by Sir James Douglass, in which signals are repeated every thirty seconds (instead of three to four minutes); this is more consistent with the present speed of vessels, — though, as Sir William Thomson insisted, much too long a time: a signal should be capable of almost instant recognition. Only red and white lights are used in these 'flashing' signals, and red but sparingly; the signals themselves occupying about ten seconds, and being, in fact, the Morse alphabet with long and short flashes. The French and English governments are doing away with stationary and revolving lights, and introducing flashing ones. Fog-horns with reeds do not stay in order; and a steam siren is to be used, high and low notes being proposed instead of long and short blasts.

Mr. W. H. Preece read three electrical papers,— The 'watt' and the horse-power; Secondary batteries; Domestic electric lighting. Secondary batteries are now an accomplished commercial fact in England, the old Faure accumulator being as good a form as any. Domestic electric lighting can now almost compete with gas, which costs in London three shillings per thousand.

Attention was called to the fact that there is no incandescent lighting in Canada; and Sir W. Thomson called attention to the water-power running to waste in the Lachine rapids. A photographic gallery in Regent Street, London, was referred to, where the electric light is used for the negative and for print-

ing, the pictures being delivered the same night. The dynamo is run by a gas-engine; and it was stated that more light could be thus had from gas, than by burning it directly. Sixteen feet of gas per hour will develop one horse-power.

Dr. W. A. Traill had a paper on the Portrush and Giant's Causeway electric tramway; and Mr. H. Smith, one on electric tramways. The former was accompanied by a working model. A review of previously constructed roads was given, and the points of difference emphasized; and the commercial success of the road was announced. Owing to the interest created by this paper, and the first two, Professor Thompson's paper on dynamo-electric machines was left over.

Mr. C. J. H. Woodbury described the 'automatic sprinkler' system in an American mill, and referred to a slow-burning construction of the latter, where heavy beams, widely separated, support a three-inch planking, on which is laid the flooring of hard wood. A large number of sprinklers have been critically compared in the interest of the insurance companies; and the result of this work showed a record favorable to the value of the apparatus, as it had operated in one hundred and forty-one mill fires, without any instance of total failure except in two instances, where the water supply had been shut off from the system. The sprinklers were tested for sensitiveness by exposing them to a jet of steam instead of a fire, because the former is more regular in its action. The resistance of the soldered joints to shearing-stress was exceedingly variable, ranging from twenty-five hundred to seven thousand pounds per square inch.

The first attempts to make sprinklers were devoted to endeavors to construct an arrangement for rigidly holding a valve to a seat; and, after these had proven failures, the method of soldering a cap over the sprinkler was next introduced. Later, Mr. F. Grinnell solved the problem, by placing the valve in the centre of a flexible diaphragm; and the arrangement of the parts was such that the water-pressure kept the valve shut until the soldered joint leaked, and then this same pressure forced the sprinkler open.

Professor Osborne Reynolds discussed the 'friction of journals.' The report of a committee on lubrication was referred to, and various methods of lubrication discussed. The method giving the best results is to let part of the shaft run in a bath of oil, which is then sucked in by the action of the shaft. With oil fed by a siphon or a plain hole, the friction is seven or eight times greater; and, in one experiment, the oil was forced out of the hole with over two hundred pounds pressure on a square inch. Professor Thurston was called upon, and gave his experience with lubricants, confirming the statements of the paper, and referring to a case in which he had used a pump to force oil to the journals. Evidently, if so much friction can be saved by copious and regular oiling, it might pay to supply journals systematically with oil under pressure.

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

PROCEEDINGS OF THE SECTION OF MATHEMATICS AND ASTRONOMY.

THE first paper read in this section was by Prof. E. C. Pickering, upon the colors of the stars. The need of exact photometric measurement of different parts of their spectra was first pointed out, and the author then described a very ingenious method of accomplishing this. In the telescope tube, a little beyond the focal plane, is a direct vision prism, so set as to give a spectrum extended in declination; and on the preceding side of this prism is placed a piece of plane glass, whose edges are so ground, that, when a small portion of the following side of the cone of rays falls upon it, it gives a small white ghost, just preceding the spectrum and always opposite the same wave-length. In the focal plane is one of Professor Pritchard's neutral-tint wedge photometers, and behind it a thin metal diaphragm with four long narrow slits parallel to the equatorial motion; so that, when the spectrum transits behind them, four little stars — a red, yellow, blue, and a violet — shine through these slits, and the time of the disappearance of each, as they move towards the thicker edge of the wedge, measures its brightness. From these times may be deduced the magnitude and color curve of the star. To fix the same wave-lengths for each observation, the little white ghost is adjusted upon one of two parallel wires, which project out beyond the preceding side of the diaphragm. For a succeeding transit, the ghost is adjusted upon the other wire, half a slit-interval distant, and thus eight points of the spectrum are photometrically measured. Professor Young, of Princeton, spoke very highly of the ingenuity and effectiveness of the device, especially for the systematic measurement of a large number of stars. He pointed out, however, what might be a source of error; viz., the different sensitiveness of different observers' eyes to different colors, so that they would probably observe the times of disappearance of the four colored stars relatively slightly different.

The next paper, by Professor Daniel Kirkwood, discussed the question whether the so-called 'temporary stars' may be variables of long period, referring to the sometimes-claimed identity of the temporary stars of 945 and 1264 with the well-known Tycho Brahe's star, which blazed forth in Cassiopeia in 1572, and whose position is pretty closely known from his measures. The conclusion reached was, that on account of the sudden apparition of the temporary stars, the short duration of their brightness, and the extraordinary length of their supposed periods, they should be considered as distinct from variables.

Professor Mansfield Merriman, the author of the well-known treatise on 'Least squares,' proposed a criterion for the rejection of doubtful observations, founded upon Hagen's demonstration of the law of frequency of error, which was simpler than Pierce's or Chauvenet's. It involves, however, a determination of what is the unit of increment between errors of different sizes, a thing difficult to determine in very many cases. Professor Harkness, of the Naval observatory, thought that in the case of a criterion for the rejection of doubtful observations, — upon which the most eminent mathematicians disagreed, — practically every one was a law unto himself. He noted the rather doubtful method of taking a large number of shots on a target-board as a good illustration of the law of frequency of error, especially in any such case as that of long-distance shooting, where, on account of the varying character of the wind, the skilful marksman will frequently change his rifle-sights an amount corresponding to twenty or thirty feet on the target, and yet make a complete series of bull's-eyes, or very close to it. Professor Rogers, of the Harvard college observatory, expressed his disbelief in the efficacy of least squares to tell the truth, illustrating it by several cases. For rejecting discordant observations, he referred to the late Professor Winlock's method of determining the personal habit and accuracy of each observer as a means of getting an empirical criterion. He closed with an expression of the opinion that the method of least squares was a method of 'covering a multitude of sins.' Professor Pickering said that we must have some criterion, and every one would practically use one of some kind. He referred to his plan of using 'average deviation' as easier to compute than 'probable error,' and considered five times the average deviation a good limit for the rejection of discordant results. Professor Stone, of the University of Virginia, referred to the very common case of only three, four, or five observations of a star, where the data are not sufficient to apply any criterion, and to the advisability, when it was possible, of making more observations to settle the question. Another speaker referred to the importance of a special search for systematic abnormal errors. Professor Rogers referred to the uncertainty of trusting to the impressions upon one's senses, and said that in nine cases out of ten, where he thought he had observed a transit over a particular wire too early or too late, it would come out just the other way. Professor Hough, director of the Dearborn observatory, thought an observer generally incapable of judging or weighting his observations according to his impressions. In the case of uncertain conditions, like an unsteady atmosphere, he thought it best to quit work and wait for better. Professor Frisby, of the Naval observatory, emphasized the danger of rejecting observations, or forming any arbitrary limit for this purpose. Professor Langley, director of the Allegheny observatory, hoped that further experience would be given upon this question of trusting one's own impressions in rejecting or weighting observations, as it was an exceedingly interesting and important one. Professor Merriman, the author of the paper, referred to the importance of eliminating all sources of systematic errors so far as possible, and of separation into groups, for separate discussion, in order to discover such errors. Professor Rogers referred to the various values of the solar parallax which had been deduced in one way or another by least squares, and another speaker referred to the hidden sources of error which least squares could not deal with. Professor Paul, assistant astronomer at the Naval observatory, said the method of least squares was hardly receiving fair treatment in the discussion, and thought the difficulty was that half or three-quarters of those who used the method failed to bear in mind the theory on which it rested: that it only applied to purely accidental errors; whereas in more than half the cases it is actually applied to errors distributed round a point which is continually moving or jumping, due to systematic sources of error or sudden disturbance, and that no attempt is made to discover and eliminate these systematic or sudden-jumping errors, but least squares is applied indiscriminately to the whole, with a sort of blind faith that it will bring good results out of poor observations, and make it all right somehow. He said that, intelligently applied, the method not only gave the most probable result, but furnished the only measure of the exactness of the observations so far as accidental errors were concerned, and at the same time the most effective method of discovering these hidden sources of systematic error. Professor Stone illustrated this by the case of combining many series of comet-observations, made at different observatories, into one orbit, without attempting to discover any systematic errors in the series of the different observers. The discussion was closed by Professor Eddy with remarks upon the necessity of some criterion dependent upon the results themselves, and independent of the observer's arbitrary judgment.

Professor Pickering then read another paper upon systematic errors in stellar magnitudes, showing, without any question, that the magnitudes of all the star-catalogues from that of Ptolemy down to the great work of Argelander in the Durchmusterung — all depending upon eye estimates — are systematically affected by being in, or close to, the Milky Way; they all being estimated too faint, and the error amounting to about half a magnitude in the Milky Way itself. This arises from the brightness of the background upon which the star is viewed. In the Harvard photometry measures, this source of error is avoided; since, in the comparison of each star with the pole-star, the two fields are superposed, and their added brightness affects both stars alike.

Prof. M. W. Harrington, director of the Ann Arbor observatory, read a paper upon the asteroid ring. He showed that the representative average orbit would be an ellipse of small eccentricity, with semi-major axis equal to about 2.7 times that of the earth, and inclined to the plane of the ecliptic about 1°; and that, in the progressive discovery of these small bodies, the average mean distance had gradually increased, but now seemed to have reached its limit. On the assumption that the surfaces of all the aster-

oids have the same reflecting power as Vesta, Professor Harrington reaches the conclusion that the volume of Vesta is about $\frac{1}{10}$ that of all these 230 bodies put together, and that Vesta and Ceres together form almost one-half the total volume.

Professor Rogers of the Harvard college observatory then read two papers. The first one, upon the magnitude of the errors which may be introduced in the reduction of an observed system of stellar co-ordinates to an assumed normal system by graphic methods, showed a great amount of laborious research, and was a good illustration of the vast amount of monotonous work necessary in the present stage of astronomical observation in order to reach the highest degree of accuracy attainable by the search for and elimination of minute systematic errors. His next paper was upon the original graduation of the Harvard college meridian circle *in situ*. This described a method of turning a meridian circle through any desired constant arc up to about 30° without any dependence upon the circle and reading microscopes, effected by means of an arm swinging between fixed stops, and clamping to a circular ring on the axis by an electro-magnetic clamp. With this Professor Rogers claimed to be able to set off a constant arc through as many as five thousand successive movements of the clamping arm. The ingenious method suggested and carried out by Mr. George B. Clark, of the firm of Alvan Clark & Sons, of grinding the clamping circle to a perfect circular form while the telescope was swung round in its Y's, was fully described, and also Professor Rogers's method of arresting the momentum of the telescope at the stops by water-buffer plungers. The great advantage of thus being able to set off a constant arc independent of the circle and microscopes was pointed out, with especial reference to the investigation of division errors and flexure of circle, and also to the division of the circle itself *in situ;* i.e., mounted on its axis and turning on its pivots. Professor Young called attention to the necessity of guarding against expansion and contraction of the bar holding the stops, due to radiation from the observer's body.

Mr. S. C. Chandler, jun., of the Harvard college observatory, gave the results of observations and experiments with an 'almucantar' of four inches aperture, a new instrument devised by Mr. Chandler, which seems to be of remarkable accuracy, and promises to furnish an entirely new and independent method of attacking some of the most important problems in exact observational astronomy. The instrument consists of a telescope and vertical setting-circle, which can be clamped at any zenith-distance, and is supported on a rectangular base which floats in a rectangular trough of mercury, the whole turning round a vertical axis so as to observe in any azimuth; these observations being simply the times of transit of any heavenly body over a system of horizontal wires in the field. The observations thus far have been entirely upon stars, and all at the apparent zenith-distance of the pole. After some very small periodic variations in the zenith-distance pointing had been traced to changes of temperature, and had been removed by sawing through the wooden bottom of the mercury trough, the instrument showed an astonishing constancy in this zenith-distance pointing, extending over weeks at a time, and far exceeding the constancy of the corrections to the best fundamental instruments of our observatories.

A paper was read by Mr. Chandler, upon the colors of variable stars. Showing, first, that most of the variables were *red*, he described some fairly satisfactory methods which he had used to measure the *degree* of redness of all the periodic variables; and then, plotting a series of points whose abscissae represented the *length* of the periods, and ordinates the *degree of redness*, their agreement with a curve making a very decided angle with the axis of abscissae brought out without question the remarkable law, that, *the redder the star, the longer is its period of variability.* In discussing any theory of variable stars, Mr. Chandler pointed out that Zöllner was the only one who had thus far taken into account two laws already known: viz., 1° that they are generally *red;* 2° that they *increase* in brightness *much more rapidly* than they *decrease;* and now, in any further theory, this new third law must have a place, viz., that, the *redder* they are, the *longer* is their period.

Monday's session opened with a paper by Dr. R. S. Ball, astronomer royal of Ireland, upon the ruled cubic surface known as the cylindroid, whose equation is

$$z(x^2 + y^2) - 2mxy = 0.$$

Mr. W. S. Auchincloss of Philadelphia exhibited a balancing-machine for finding the centre of gravity of any number of different weights distributed along a line, which seemed to be of excellent construction, extremely easy and rapid in manipulation, and quite sensitive. In connection with a time-scale of three hundred and sixty-five days at one side, it was shown how rapidly a complicated system of business accounts could be settled, and how it could be applied to various engineering problems.

The next paper was by Prof. J. H. Gore, of the U S. geological survey, upon the geodetic work of the U. S. coast and geodetic survey. This was a long paper, much of it devoted to a historical *résumé* of geodetic work in all countries. The points of principal interest brought out were the great advantages possessed by the United States in its vast extent of territory, for determining the figure of the earth; and the work already done along the coasts, and along a chain of triangles from the Atlantic to the Pacific, was shown on a map. The great accuracy attained, especially in base-measurement, was noted, and the great improvements made in apparatus and instruments of the survey. Especially was the importance insisted on of a scientific body like the American association supporting in every way the integrity and unity of this great work. In answer to questions, Professor Gore stated that the most recent improvements in the base-measuring apparatus were the determination of the coefficients of expansion for every degree of temperature to which they would be exposed; and he expressed his belief that results

more accurate still would be attained by immersing them in melting ice, so as to keep them at a constant temperature when in actual use.

The next paper was by Mr. J. N. Stockwell of Cleveland, upon an analysis of the formula for the moon's latitude as affected by the figure of the earth. In this Mr. Stockwell claimed that Laplace's formula for expressing this was wrong; the question turning upon an approximate integration of a differential equation, which he claimed to show was wrong by separating into two terms a single one which expressed the difference of two effects, which, thus evaluated separately, became either indeterminate or of an impossible amount.

Prof. J. C. Adams of Cambridge, England, made some comments upon Mr. Stockwell's paper, the audience eagerly crowding forward that they might lose none of the interesting discussion. Professor Adams spoke in high terms of the general work which Mr. Stockwell had done in the difficult subject of the lunar theory; but, from such conclusions and methods as those brought forward in this particular case, he said he must express his total dissent. He then, in the simple yet forcible manner of a master of mathematical analysis, pointed out that this equation was, to begin with, only an approximation; that, before it could be treated at all as a rigorous one, many other small terms must be included; that, further, its integration was only an approximation; and that in this case, any separation into terms, which, on a certain approximate assumption, became either indeterminate or very large, was of no value as a test of the equation; that, in the case of oculating elements referred to by Mr. Stockwell, these in no sense represented an average orbit, but only an instantaneous state of ever-varying elements; and that any integration proceeding on the first hypothesis, over a long period, would introduce an error increasing with the time which would swallow up entirely the perturbations sought. The celebrated astronomer, than whom neither England nor the whole continent of Europe could have sent one more competent to advise, then closed with a few remarks pregnant with suggestion to workers in the lunar theory, upon the general methods to be followed in these long and difficult solutions by *approximations*. Hearty applause followed; and the animated discussion was brought to a good-natured close, Mr. Stockwell still unconvinced, hoping that when Professor Adams had given more attention to this particular point, he would come to think the same of it as himself; and Professor Adams (amid much laughter) hoping that day would never come.

In Tuesday's session, Professor Ormond Stone, director of the Leander McCormick observatory of the University of Virginia, gave an elaborate description of that observatory now approaching completion, and to be devoted entirely to original research. The telescope, which will soon be mounted, is the twin in size of the Washington twenty-six inch, and like it in most of its details, except the driving-clock, which is like that of the Princeton twenty-three inch, with an auxiliary control by an outside clock, and that it has Burnham's micrometer illumination. The observatory has a permanent fund of seventy-six thousand dollars as a beginning; and eighteen thousand dollars have been expended in observatory buildings, and eight thousand dollars for the house of the director. Situated eight hundred and fifty feet above the sea, and on a hill three hundred feet above surroundings, the main building, circular in shape, is surmounted by a hemispherical dome forty-five feet in diameter. The brick walls have a hollow air-space, with inward ventilation at bottom and outward at top. Mr. Warner, the builder of the dome, gave an interesting description of the ingenious method of adjusting the conical surfaces of the bearing-wheels, so that they would, without guidance, follow the exact circumference of the tracks; and then of the adjustment of the guide-wheels, so that the axis of this cone should be exactly normal to the circular track. The framework of the dome consists of thirty-six light steel girders, the two central parallel ones allowing an opening six feet wide. The covering is of galvanized iron, each piece fitted *in situ*, and the strength of the frame is designed to stand a wind-pressure of a hundred pounds per square foot. There are three equal openings with independent shutters, the first extending to the horizon, the second beyond the zenith, and the third so far that its centre is opposite the division between the first and second. The shutters are in double-halves, opening on horizontal tracks, and connected by endless chain with compulsory parallel motion of the ends. The dome weighs twelve tons and a half, and the live-ring one ton and a half; and a tangential pressure of about forty pounds, or eight pounds on the endless rope, suffices to start it. If this ease of motion continues as the dome grows old, it is certainly a remarkable piece of engineering work.

In the discussion which followed, Professor Hough said that he should prefer the old style of single opening extending beyond the zenith. Professor Stone could not agree with him, the greater extent of opening making it less probable that the dome would have to be moved so far in turning from star to star, and at the same time furnishing better ventilation, and the opportunity for cross-bracing adding strength to the dome. He stated that he should first take up the re-measurement of all the double stars of less than 2″ distance between 0° and −30°.

Father Perry, the director of the observatory at Stonyhurst, Eng., gave the result of late researches on the solar surface, with special reference to evanescent spots. No abstract can give any idea of the wide range of interesting topics covered in this paper. The multitude of ever-changing details to be observed on the sun, and the careful record of these which is kept at the Stonyhurst observatory, furnished the material for a paper replete throughout with new and important details, to which nothing but a publication in full can do any justice whatever; and it is to be hoped that the association will soon give the public the opportunity to read it in this way.

On Wednesday, Mr. Lewis Swift, director of the Warner observatory at Rochester, N.Y., read a paper upon the nebulae, in which he described his method

of search for new nebulae, and of simply recording their approximate positions by pointing with unilluminated cross-wires in the eye-piece, and reading off the circles of the instrument, recording with this a description of the appearance of the nebula. His reason for making no attempt to determine accurate positions was that it would require illuminated micrometer-wires, and a great deal of time devoted to measurement with neighboring stars, besides much time lost in letting the eye become sensitive again for further search or examination after the light was removed; he stating that his eye was practically 'nebula blind' for at least four minutes after being near a light. Since, however, the most of these nebulae are probably too faint to bear any illumination at all, and must therefore be observed for position with ring or bar-micrometer, much of this reason loses its force; for in this case there would be no loss of time on account of light, and if in this way Mr. Swift could connect each of these new nebulae to some neighboring star with the help of chronograph or an assistant at clock or chronometer, and also re-observe the known nebulae in the same way, the value of the work would be almost immeasurably increased compared with the little additional time and labor necessary for its accomplishment. As it is, though no one will deny the value of a catalogue of even the approximate positions and descriptions of very faint nebulae, as a contribution to our knowledge of their number and distribution, and as an aid in comet-seeking or identification, yet it is fairly open to the criticism, that, to be what it should be in the present state of astronomical observation, it must all be gone over again for determinations of accurate positions. One very interesting statement of Mr. Swift, to the effect that there had not been a first-rate clear sky since the red glows appeared a year ago following the Krakatoa explosions, bears out the general experience of workers in other observatories, especially those who try to see stars near the sun in the daytime.

An interesting discussion arose as to the much-disputed existence of the nebula round the star Merope in the Pleiades; the general drift of it being that the nebula no doubt existed, but in order to see it a clear sky was necessary, and a very low power and large field, so that the nebula might be contrasted with darker portions of the same field; that a large telescope was not necessary, in fact the smaller the better, provided the optical qualities were relatively as good. Mr. Swift said he could always see it under favorable conditions; and Mr. E. E. Barnard of Nashville, Tenn., the discoverer of the latest comet, said that before he knew of its existence at all, he picked it up as a supposed comet.

On Thursday Professor Adams of Cambridge, Eng., read a paper upon the general expression for the value of the obliquity of the ecliptic at any given time, taking into account terms of the second order. The difficulties of obtaining a formula for this quantity, on account of the many varying elements upon which it depends, were clearly explained by a diagram, and the results given of an approximation carried much further than ever attempted heretofore.

Professor Harkness, in paying a high compliment to the celebrated mathematician and astronomer for these laborious and valuable researches, also expressed a wish that some of the n-dimensional-space mathematicians would follow the example of Professor Adams, and apply some of their superfluous energy to the unsolved problems in the solar system, which have some direct practical bearing.

Professor Newcomb, in remarking upon the mass of the moon used in this problem, expressed the opinion that this could be obtained most accurately by observations of the sun, in determining the angular value of the radius of the small circle described by the earth about the common centre of gravity of earth and moon, since this, in his opinion, seemed to be the only constant which could be determined by observation absolutely free from systematic errors, and hence was capable of an indefinite degree of accuracy by accumulated observations; and he asked Professor Adams's opinion on this point.

The latter replied, that he thought the quantity too small for *certain* accurate determination, almost beyond what could be actually seen by the eye in the instruments used.

Professor Newcomb admitted, in the case of *absolute* determinations, the general impossibility of attempting to measure what cannot be seen; but, in the case of *differential* or *relative* determinations in which there was no supposed possibility of constant or systematic errors, he advanced the theory, which he had thought of elaborating more fully at some time, that such determinations might be carried by accumulated observations to a sure degree of accuracy far beyond what can be seen or measured by the eye absolutely.

Professor Adams hoped he would more fully elaborate and publish this idea, since there was in it an element well worth careful consideration.

Professor Harkness doubted the sufficient accuracy of meridian observations of the sun, on account of the distortions produced by letting the sun shine full into the instrument; and spoke of the difficulties in the transit-of-Venus observations from this cause.

Professor Newcomb replied that he would have to show that this would be periodic with reference to the moon's quarters in order to affect this constant systematically.

Professor Adams then presented another note upon Newton's theory of atmospheric refraction, and on his method of finding the motion of the moon's apogee. He described in an exceedingly interesting manner how some unpublished manuscripts of the great geometer had lately come into his hands at Cambridge, which contained later work than is published in the Principia. Space will not allow a description of the methods which these papers show that Newton employed in attacking, and remarkably successfully too, some of the problems which still trouble astronomers to-day. Photographs of these papers were exhibited, showing his wonderful neatness and precise methods in computation. It was something of a novelty to those gathered on this occasion, to hold in their hands the facsimiles of the

handwriting and computations of this intellectual giant, whose works will for all time be the greatest wonder to him who studies them the most.

With the hearty thanks of the section to Professor Adams for his exceedingly interesting communications, it was then adjourned.

PROCEEDINGS OF THE SECTION OF PHYSICS.

THE meeting of the American association was one of unusual interest and importance to the members of section B. This is to be attributed not only to the unusually large attendance of American physicists, but also to the presence of a number of distinguished members of the British association, who have contributed to the success of the meetings not only by presenting papers, but by entering freely into the discussions. In particular the section was fortunate in having the presence of Sir William Thomson, to whom more than to any one else we owe the successful operation of the great ocean cables, and who stands with Helmholtz first among living physicists. Whenever he entered any of the discussions, all were benefited by the clearness and suggestiveness of his remarks.

Among the members of the British association who were present, may also be mentioned Professor Fitzgerald of the University of Dublin, Professor Silvanus P. Thompson, Mr. W. H. Preece, superintendent of the English postal telegraph, Professor Forbes, and Professor Schuster of the Cavendish laboratory.

Among American physicists there were Professors Trowbridge, Rowland, Barker, Mendenhall, Hall, Hastings, Bell, Anthony, Brackett, Rogers, Pickering, Cross, and many others. The section was organized on Thursday, Sept. 4, and the opening address delivered by the vice-president, Professor Trowbridge. The time devoted to the reading and discussion of papers was unfortunately much infringed upon by the Electrical conference: yet, considering this serious interruption, the number of interesting discussions was unusually large.

It is not to be expected that the elaborate investigation of the relation of the yard to the metre, such as was the subject of a paper by Professor William A. Rogers, will be of very general interest. Yet to the physicist such a comparison, conducted by one who has had the long experience of Professor Rogers, is of the highest importance in giving accuracy to determinations of length. Professor Rogers has given his life to perfecting the construction and testing of standards of length, and the result of this his latest investigation is that the metre is 39.37027 inches in length. One of the most important physical measurements is that of the wave-length of light of any given degree of refrangibility, and this determination is best made by means of the diffraction grating. On account of the extensive use of the magnificent gratings constructed by Professor Rowland for this purpose, Professor Rogers instituted an investigation to determine the coefficient of expansion of the speculum-metal used in the construction of these gratings. He also noted that from its homogeneity, fineness of grain, and non-liability to tarnish, this speculum-metal is peculiarly suitable for constructing fine scales, though its extreme brittleness is an objection to its use for large scales. Professor Rowland stated that he proposed to construct scales on his ruling-engine which would enable the physicist at any time, by purely optical means, and without knowing the coefficient of expansion of the metal or its temperature, to obtain the value of the length of the scale in terms of the wave-length of any given ray of light. These scales were simply to be straight pieces of speculum-metal ruled with lines just as an ordinary grating, except that the length of the lines is to be only about one centimetre, every one-hundredth line being somewhat longer than its neighbors: the whole ruled strip is to be one decimetre in length. From the manner of ruling, it will be easy to count the whole number of lines in the length of the strip, and then by a simple use of the scale as a grating in a suitable spectrometer the whole length may be immediately found at any time in terms of any specified wave-length of light.

In some forms of telephones and in the microphone, the action depends on the change in resistance of a small carbon button on being subjected to pressure. There has been much discussion as to whether this diminution of the resistance with pressure is due to a change in the resistance of the carbon itself, or simply to the better contact made between the carbon and the metallic conductor when the pressure is applied. Professor Mendenhall has carried out some experiments to determine the question; and one of his methods of experimenting — that with the hard carbons — appears to point conclusively in favor of the theory that the resistance of the carbon itself is altered by pressure. The experiments made by him on soft carbon are open to criticism, though they also point to the change taking place *in* the carbon. Professor Mendenhall finds that the resistance is not simply proportional to the pressure, and thinks that by increasing the pressure a point of maximum conductivity would be reached where there would be no change in resistance for a small change in pressure.

Prof. A. Graham Bell, the inventor of the telephone, read a paper giving a possible method of communication between ships at sea. The simple experiment that illustrates the method which he proposed is as follows: Take a basin of water, introduce into it, at two widely separated points, the two terminals of a battery-circuit which contains an interrupter, making and breaking the circuit very rapidly. Now at two other points touch the water with the terminals of a circuit containing a telephone. A sound will be heard, except when the two telephone terminals touch the water at points where the potential is the same. In this way the equipotential lines can easily be picked out. Now, to apply this to the case of a ship at sea: Suppose one ship to be provided with a dynamo-machine generating a powerful current, and let one terminal enter the water at the prow of the ship, and the other be carefully insulated, except at its end, and be trailed behind

the ship, making connection with the sea at a considerable distance from the vessel; and suppose the current be rapidly made and broken by an interrupter: then the observer on a second vessel provided with similar terminal conductors to the first, but having a telephone instead of a dynamo, will be able to detect the presence of the other vessel even at a considerable distance; and by suitable modifications the direction of the other vessel may be found. This conception Professor Bell has actually tried on the Potomac River with two small boats, and found that at a mile and a quarter, the farthest distance experimented upon, the sound due to the action of the interrupter in one boat was distinctly audible in the other. The experiment did not succeed quite so well in salt water.

Professor Trowbridge then mentioned a method which he had suggested some years ago for telegraphing across the ocean without a cable; the method having been suggested more for its interest, than with any idea of its ever being put in practice. A conductor is supposed to be laid from Labrador to Patagonia, ending in the ocean at those points, and passing through New York, where a dynamo-machine is supposed to be included in the circuit. In Europe a line is to extend from the north of Scotland to the south of Spain, making connections with the ocean at those points: and in this circuit is to be included a telephone. Then any change in the strength of the current in the American line would produce a corresponding change in current in the European line; and thus signals could be transmitted. Mr. Preece, of the English postal telegraph, then gave an account of how such a system had actually been put into practice in telegraphing between the Isle of Wight and Southampton during a suspension in the action of the regular cable communication. The instruments used were a telephone in one circuit, and in the other about twenty-five Leclanché cells and an interrupter. The sound could then be heard distinctly; and so communication was kept up until the cable was again in working-order. Of the two lines used in this case, one extended from the sea at the end of the island near Hurst castle, through the length of the island, and entered the sea again at Rye; while the line on the mainland ran from Hurst castle, where it was connected with the sea, through Southampton to Portsmouth, where it again entered the sea. The distance between the two terminals at Hurst castle was about one mile, while that between the terminals at Portsmouth and Rye amounted to six miles.

A few years ago Mr. E. H. Hall, then a student at the Johns Hopkins university, taking a thin strip of gold-leaf through which a current of electricity was passing, and joining the two terminals of a very sensitive galvanometer to two points in the gold-leaf, one on one edge, and the other on the other, choosing the points so exactly opposite that there was no current through the galvanometer, found that on placing the poles of a powerful electro-magnet, one above and the other below the strip of gold-leaf, he obtained a current through the galvanometer, thus indicating that there was a change in the electric potential, due to the action of the magnet. Mr. Hall explains this change by supposing the rotation of the equipotential lines in the conductor about the lines of magnetic force. This explanation has been brought into question by Mr. Shelford Bidwell, who attempts to explain the action thus: The magnetic force acting on the conductor carrying the current would cause the conductor to be moved sideways, were it free to move; but, since it is held by clamps at the ends, the magnetic force acting upon it brings it into a state of strain, one edge being compressed and the other stretched; and Mr. Bidwell supposes the whole Hall effect to be due to thermal actions taking place in consequence of this unsymmetrical state of strain. Professor Hall, who is now at Harvard, has made some careful experiments to test this explanation of Mr. Bidwell. He used not only gold-leaf, but strips of steel, tinfoil, and other metals, and clamped them sometimes at both ends, sometimes in the middle, and sometimes only at one end; and in all cases the action was the same, with the same metal, irrespective of the manner of clamping. This was strong evidence against Mr. Bidwell's position. Sir William Thomson suggested, as a further test, to bring about the state of strain, which Mr. Bidwell supposes to be the primary cause of the action, by purely mechanical means, bringing pressure to bear on one side or the other, and seeing whether the action obtained is at all commensurate with the action found by Mr. Hall.

Professor Hall then discussed an experiment by which Mr. Bidwell had obtained a reversal of the effect; and showed that the reversal was only apparent, and that when carefully examined the results of Mr. Bidwell's experiment were best satisfied by the theory of the rotation of the equipotential surfaces about the lines of magnetic force. Sir William Thomson spoke of the discovery of Mr. Hall as being the most important made since the time of Faraday. He favored Mr. Hall's explanation; though he considers Mr. Bidwell's suggestion as very important, and thinks that it will very likely be found that both the Hall effect and thermal effects have a common cause, rather than that one is to be taken to explain the other. He showed also that the mathematical examination of the subject indicates three relations to be investigated, — first, the relation of thermal force to the surfaces of equal rate of variation of temperature; second, the relation of electric current to the equipotential surfaces; third, the relation of the thermal flow to isothermal surfaces. The second of these is that investigated by Mr. Hall, who has found that under the conditions mentioned the lines of flow are *not* perpendicular to the equipotential surfaces. There remains, therefore, 'work for two more Halls,' in either proving or disproving the existence of the analogous actions in these other two cases. Sir William Thomson also suggested the following exceedingly interesting mechanical illustration or analogue of Hall's effect. Let us be living upon a table which rotates uniformly forever. A narrow circular canal is upon this table, concentric with the axis of rotation of the table, and nearly

full of water. After a while the water will acquire the same velocity of rotation as the table, and will come to a state of equilibrium. The outer edge of the water in the canal will then stand a little higher than the inner edge. Let us now apply a little *motive* force to the water, and by means of a pump cause it to flow in the canal in the same direction in which the table is already rotating: it is evident that it will stand higher on the outer edge, and lower on the inner edge of the canal, than before. But, should we cause it to flow in the opposite direction to the motion of the table, it will stand lower on the outer edge, and higher on the inner edge, than in its position of equilibrium.

The experiment made by Mr. Shelford Bidwell may also be illustrated by putting a partition in the canal so as to divide it into two circular concentric troughs, and making a little opening in the partition at some point; then taking two points near the opening in the partition, one in one trough and one in the other, if they are very close to the partition, the point in the outer trough will be at a *lower* level than that in the inner one; but if they are not close to the partition, but one is taken close to the outer edge of the outer trough and the other close to the inner edge of the inner trough, then the point in the outer trough will be at a *higher* level than that in the inner trough, though the difference in level will be only about half of what it would have been had there been no partition separating the canal into two troughs. Professor Forbes called attention to the fact that the classification of the metals according to their thermo-electric qualities gives not only exactly the same division into positive and negative, but that the very *order* obtained in that way corresponds to that obtained by classifying according to the Hall effect, except *possibly* in the case of aluminium.

Prof. Silvanus P. Thompson read a paper on the government of dynamo-machines. It is a subject of considerable importance from the practical point of view, and Professor Thompson has given a great deal of thought to it. After reviewing and criticising the methods used by Marcel Desprez and Ayrton and Perry, he proposed a method devised by himself, and which he has successfully employed. It was what he calls a dynamometric method, since it is based on the employment of a transmitting dynamometer as a governor. In this way the governing action is made proportional to the rate of work. Professor Thompson's very simple device is to have resistance-coils so placed in the pulley of the transmitting dynamometer, which is fixed to the shaft, that as the rate of work varies, and the movable pulley of the dynamometer changes its position with reference to the fixed pulley, resistance will be added to or taken from the circuit; thus modifying the current, and bringing about the required government.

An interesting paper was also read by Professor Wead, in which he gave the results of some experiments made on the energy absorbed by organ-pipes in producing sound. Among other things, he showed that reeds are very much more efficient than pipes, giving far louder sound with less expenditure of energy. He also showed that the results of his experiments, on the energy absorbed by pipes of similar shape but different pitch, confirm the practical rule adopted by organ-builders in increasing the proportional diameter of the pipes as the pitch increases, so as to maintain equal loudness. Professor Wead finds, that for a rise in pitch of sixteen semitones, one-half the energy is required in order to give a scale of sensibly equal loudness.

Professor Loudon read a very interesting paper, giving simple geometrical constructions for determining the cardinal points of a thick lens or a system of thick lenses. It is to be hoped that he may publish his paper in full.

Many other papers were read of more or less interest, but those given are the most important.

NOTES AND NEWS.

It may be well to call attention once more to the course of eighteen lectures by Sir William Thomson, on molecular dynamics, at the Johns Hopkins university in October. Professors and students of physics are invited to attend.

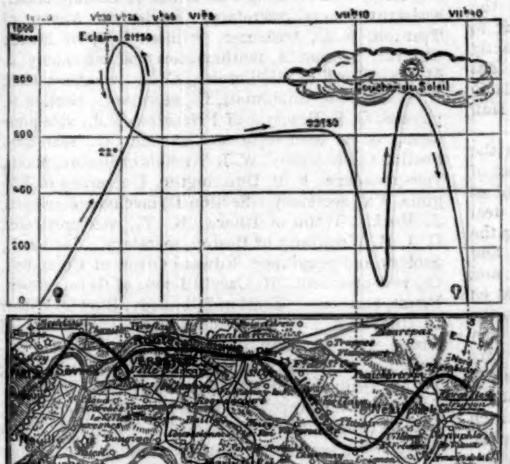
— The following persons were elected officers of the American association for the advancement of science for the ensuing year: President, H. A. Newton of New Haven, Conn.; permanent secretary, F. W. Putnam of Cambridge (office, Salem, Mass.); general secretary, Charles Sedgwick Minot of Boston, Mass.; assistant general secretary, Charles C. Abbott of Trenton, N.J.; treasurer, William Lilly of Mauch Chunk. Section A, mathematics and astronomy, J. M. Van Vleck of Middletown, Conn., vice-president; E. W. Hyde of Cincinnati, O., secretary. Section B, physics, C. F. Brackett of Princeton, N.J., vice-president; A. A. Michelson of Cleveland, O., secretary. Section C, chemistry, W. R. Nichols of Boston, Mass., vice-president; F. P. Dunnington, University of Virginia, Va., secretary. Section D, mechanical science, J. Burkitt Webb of Ithaca, N. Y., vice-president; C. J. H. Woodbury of Boston, secretary. Section E, geology and geography, Edward Orton of Columbus, O., vice-president; H. Carvill Lewis of Germantown, Penn., secretary. Section F, biology, Burt G. Wilder of Ithaca, N.Y., vice-president; M. C. Fernald of Orono, Me., secretary. Section G, histology and microscopy, S. H. Gage of Ithaca, N.Y., vice-president; W. H. Walmsley of Philadelphia, Penn., secretary. Section H, anthropology, W. H. Dall of Washington, D.C., vice-president; Erminnie A. Smith of Jersey City, N.J., secretary. Section I, economic science and statistics, Edward Atkinson of Boston, Mass., vice-president; J. W. Chickering of Washington, D.C., secretary.

— The next meeting of the British association will be held at Aberdeen.

— It was suggested by Capt. Bedford Pim, at Philadelphia, that the 1886 meeting of the American association should be held in London. It is understood that there is no constitutional obstacle in the way of the association meeting outside of America; and it

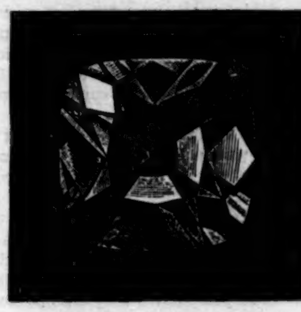
is possible that through the efforts of Capt. Bedford Pim an invitation may be received from the city of London.

—Dr. Dobell, in writing to the London *Times*, directs attention to a method of destroying cholera and typhoid germs, in drinking-water, by passing through it an electric current, and thereby exposing it to the influence of nascent oxygen, by which means the water would be dezymotized. This suggestion of Dr. Dobell's seems to have been forestalled by the construction of a filter invented by Dr. Stephen H. Emmons, which is now on view at the offices of the Economic electric company in London. The filter consists of an earthenware vessel, in which are placed porous cells containing carbon plates, the spaces between the plates and the cells being partially filled with animal charcoal. The plates are coupled up with the positive pole of a Leclanché battery or of one of the company's own chromozone batteries. Alternating with the porous cells are other carbon plates, which are coupled up with the negative pole of the battery. The water is supplied into the porous cells, and passes through the charcoal to the exterior of the cells, and is drawn off by a tap in the usual way. It is claimed, that by this means, the water being submitted to the influence of the evolved nascent oxygen, as suggested by Dr. Dobell, the *materies morbi* of typhoid, cholera, and similar diseases are destroyed, and that an end is put to the dreaded danger of, 'death in the pot.'



—The 7th of last August was signalized in France by three balloon ascensions. Gaston Tissandier and Georges Masson, the editor and publisher of *La nature*, made an ascent from Paris (a diagram of the course of which we reproduce from that journal), which occupied three hours and twenty minutes. While they were in the air, Shoste crossed for a second time the English channel; starting alone from Boulogne at 7 P. M., and descending at 9.50 P.M. at New Romney. In the evening, Hervé made an ascension at Paris in a balloon provided with some aëronautic apparatus constructed on a new system.

—Among the diamonds reserved from the approaching sale of the crown jewels of France is the Regent, so-called, which is retained on account of its mineralogical rarity, its perfect shape, its limpid



color, great size, and fame. According to *La nature*, from which we take the accompanying illustration representing its exact size, it is the largest brilliant known.

—In lecturing at the Health exhibition, on cholera and its prevention, Mr. de Chaumont expressed his opinion, that, "in regard to disinfectants, there is but one true disinfectant; viz., fire. The majority of so-called disinfectants are simply deodorants. The idea that tobacco-smoke or the odor of camphor is destructive of contagion is still extensively held, though it is simply absurd. A true disinfectant is a substance that will kill the germ or living particle in which the contagious principle resides, or through which it is conveyed."

On the other hand, Mr. de Cyon, at a séance of the Académie des sciences on July 21, recommended as a prophylactic against cholera, boracic acid, or a solution of borax, to be applied to all the external mucous membranes, and about six grains of borax to be taken with the food and drink every twenty-four hours.

—At a meeting of the Association of public sanitary inspectors in London, on Aug. 11, Mr. Edwin Chadwick read a paper on preparations for meeting the cholera, giving his experiences of the action of the board of health in the visitation of 1848–49. It would be in accordance, he thought, with the previous advances of the disease in periodic bounds upon Europe, that it should sooner or later again visit England. The practice of quarantine he considered useless and mischievous. The last decade had shown a reduction of the sickness and death-rate by nearly three-quarters of a million, and a saving of some four millions of money, incontestably from the reduction of the foul-air diseases operated upon by the services of the sanitary inspectors.

— Among the celebrities at the Medical congress at Copenhagen were Virchow, Pasteur, Lister, Volkmann, Esmarch, Spencer Wells. Pasteur's address on the prophylactic inoculation for hydrophobia was the sensation of the congress. In professional circles there are still many sceptics, and Pasteur still hesitates to try his experiments on man. The French committee appointed by Mr. Fallières are watching his experiments in Paris. Pasteur believes in the existence of special microbes of the disease, but has not discovered any as yet. Professor Andeli of Rome spoke on the causes of malaria: the primary cause he considered to be subterranean water, and the subsidence of the top soil. In conjunction with the necessary draining, he recommended as a remedy a careful use of arsenic, with the treatment with quinine. Professor Verneuil of Paris continued the subject on the same lines. At the third sitting, Sir William Gull spoke on the formation of an international institute for the study of diseases; and his resolution was passed, forming the following international committee for the purpose: for Germany, Ewald and Bernhard; France, Bouchard, Levine; Great Britain, William Gull, Humphrey, and Mac Cormac; with Professor Owen as general secretary. On the 15th, Professor Virchow spoke on 'Metaplasia;' and on the 16th the congress closed with Professor Panum's address on 'The food of healthy and unhealthy men.' The next congress will be held at Washington, in 1887. Professor Virchow's closing address was received with immense applause.

— On June 30, in Bremen, a technical commission met to discuss the export of German coal. The question whether a German coal-export company should be formed was answered in the affirmative; but a preliminary committee of inquiry was elected to report on the capabilities of foreign markets, to study their relative positions, and to make representations to the Prussian minister of railways as to tariff regulations and the improvement of loading and unloading arrangements at the harbors.

The August number of the *Kansas City review of science and industry* contains an enthusiastic article on meteorological discoveries, by Isaac P. Noyes of Washington, in which the weather-map is extolled as the basis of progress in meteorology. While many will agree with the writer, that the daily maps of the weather are of great value, it seems that he places too great importance on the 'highs' and 'lows,' as he terms barometric elevations and depressions in accordance with what may be styled signal-service slang; and that he gives too little credit to what was known before the advent of weather-maps. The following quotation illustrates Mr. Noyes's low opinion of earlier studies: "Until we had this wonderful weather-map, we had little or no conception of the meteorological phenomena of the world. For example, the tornado. The old 'physical geography' system had various names for this violent phenomenon, such as *cyclone, hurricane*, and *tornado*, and undertook to draw a line between them, giving certain characteristics to one which it did not give to the other. The map reveals the fact that they are all one and the same, and that they proceed from 'low'" (p. 202). But this opinion is certainly open to criticism; for if any fact is well proved by the weather-maps, it is that tornadoes are essentially different from cyclones, instead of being one and the same with them. A somewhat broader and more careful study of the old system, as well as of the newer weather-maps, might again suggest amendments to such assertions as these: "The violent windstorm we call tornado or cyclone when it occurs will always be in the track of 'low,' and generally at an acute angle thereto" (p. 202); "The cause of low barometer we ascribe to concentrated heat" (p. 198). The confusion of terms and error of statement in the first of these extracts, and the vagueness of explanation in the second, are especially unfortunate in an article seemingly intended for popular instruction.

— We reproduce from *Science et nature* a picture of the statue of the Marquis Claude de Jouffroy, executed by Charles Gautier, erected at Besançon, France, and inaugurated last month. De Jouffroy was the first to make a serious attempt to apply steam to navigation after Papin's experiments in 1707. De Jouffroy's first experiments were made on the Seine in 1775, and the Doubs in 1776, and afterwards more successfully on the Saône at Lyons in 1780.